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## NOTES ON FISHES IN THE INDIAN MUSEUM, XLII, XLIII.

By SUNDER LAL HORA, D.Sc., F.R.S.E., F.N.I., Assistant Superintendent,

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### XLII. ON THE SYSTEMATIC POSITION OF THE INDIAN SPECIES OF *SCAPHIODON* HECKEL.

Day<sup>1</sup> described five species from India in the genus *Scaphiodon* Heckel, and divided them into two groups on the presence or absence of barbels. The first group comprising two species—*S. watsoni* Day and *S. irregularis* Day—from the Sind Hills and the Salt Range, Punjab, is characterized by the possession of “A pair of maxillary barbels. Last undivided dorsal ray osseous, serrated”. From their descriptions, it is also clear that they possess 7 branched rays in the anal fin, as is characteristic of other species of the genus known from Baluchistan, Southern Persia, Mesopotamia and Syria. The second group comprises three species—*S. thomassi* Day, *S. nashii* (Day) and *S. brevidorsalis* (Day)—which are found in the Western Ghats as low as the Nilgiri Hills. In these forms the barbels are absent, the last undivided ray of the dorsal fin is smooth and the anal fin is generally provided with 5 branched rays. The distinguishing features of the two groups make it abundantly clear that they are not congeneric and that *Scaphiodon*, as recognised by Day, is a heterogeneous assemblage of diverse forms.

In his note on *Cirrhitina afghana* Günther, Berg<sup>2</sup> showed that the Sind and Punjab species of *Scaphiodon* belong to *Cyprinion* Heckel which is characterized by the following salient features :—

- i. Seven branched rays in the anal fin.
- ii. A more or less developed scaleless furrow between the occiput and the origin of the dorsal fin.
- iii. Dorsal with an osseous ray serrated behind and with 9-16 branched rays.
- iv. Scales subcircular.
- v. Barbels 2, angular.
- vi. Intestinal canal very long, with many convolutions.
- vii. Posterior chamber of the air-bladder long and narrow.

Berg also gave a preliminary list of all the species of *Cyprinion* belonging to the *watsoni*-group [small forms with (9) 10-11, mostly 10, branched rays in the dorsal and occurring in Southern Persia, Baluchistan, Sind and the Salt Range], with their respective synonyms and range of distribution. There would thus seem to be no uncertainty about the systematic position of the Indian species belonging to *Cyprinion* Heckel. For a general account and good figures of this type reference may be made to my<sup>3</sup> account of *Scaphiodon readingi*, which, according to Berg, is synonymous with *Cyprinion irregulare* (Day).

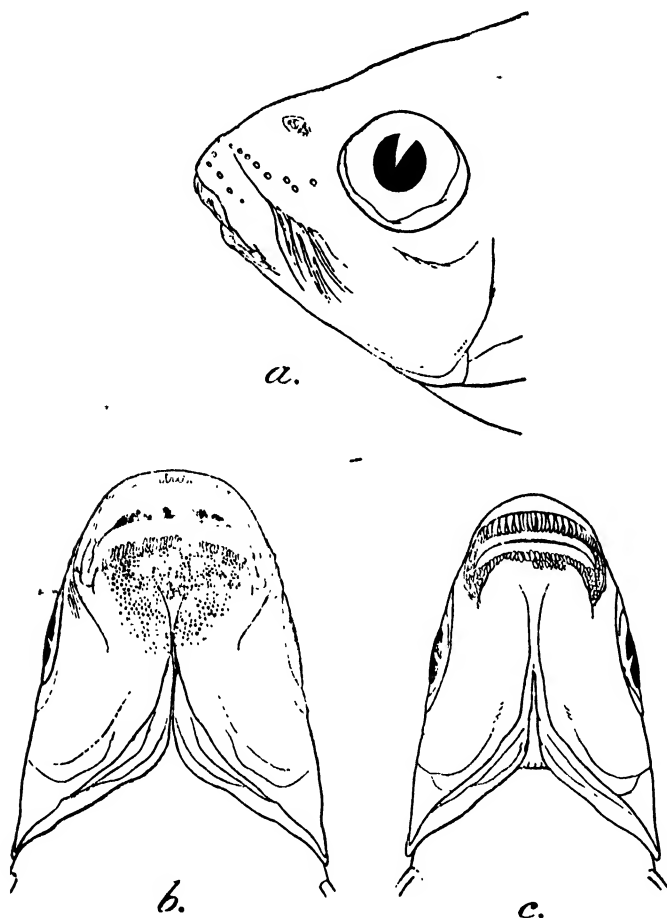
<sup>1</sup> Day, F., *Fish. India*, p. 551 (1877); *Faun. Brit. Ind. Fish.* I, p. 283 (1889).

<sup>2</sup> Berg, L. S., *Rec. Ind. Mus.* XXXV, pp. 193-196 (1933).

<sup>3</sup> Hora, S. L., *Rec. Ind. Mus.* XXV, p. 379, pl. viii (1923).



Though Berg has recently shown that *Cirrhhina afghana* Günther is a synonym of *Cyprinion microphthalmum* (Day), it may be noted that Day<sup>1</sup> was already familiar with the fact that Günther's species belonged to *Scaphiodon*, for, in referring it to the synonymy of *S. irregularis*, he observed "Not only does this fish differ from those of the



TEXT-FIG. 1.—*Osteochilus (Osteochilichthys) thomassi* (Day).

a. Lateral view of head of one of Day's specimens (No. 2192):  $\times 1\frac{2}{3}$ ; b. Ventral surface of head of same:  $\times 1\frac{2}{3}$ ; c. Ventral surface of head of a young specimen (No. F12430/1):  $\times 3\frac{1}{3}$ .

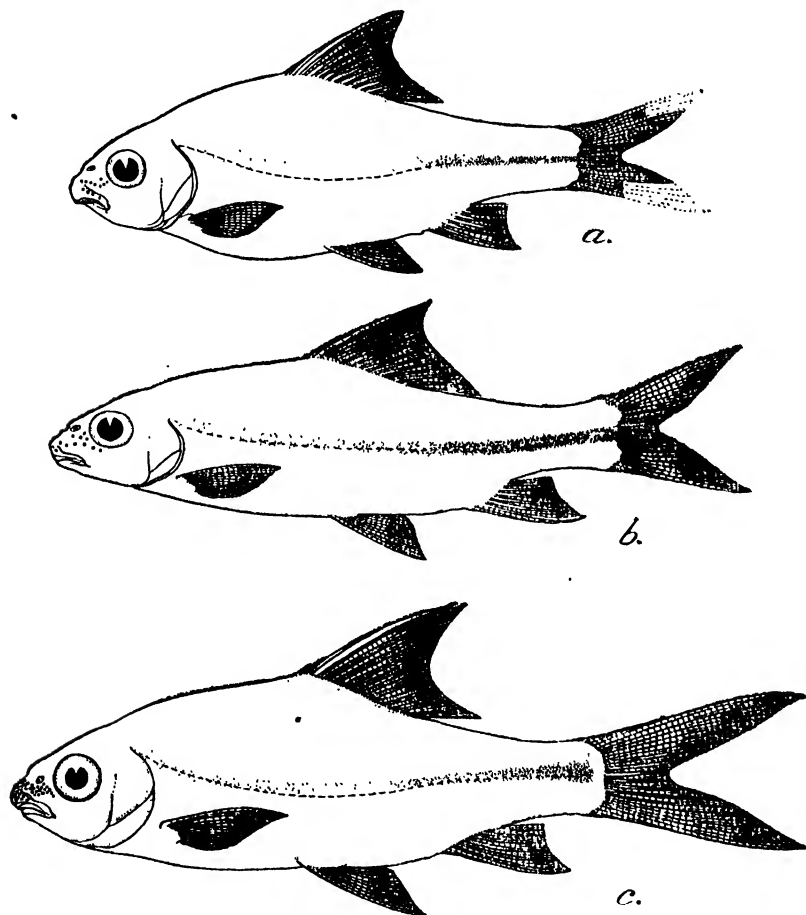
genus *Cirrhhina* in the character of its mouth, but it likewise possesses a serrated osseous ray in the dorsal fin".

The position of the three South Indian species is somewhat difficult to define, for they not only differ in fundamental characters from *Cyprinion* and allied genera, but also among themselves in several important features. For instance, in *Scaphiodon thomassi* the lips are stated to be discontinuous, "the upper one fringed. Large pores on the snout and upper lip, and a line of them continued to under the eye". The

<sup>1</sup> Day, F., *Fish. India, Suppl.*, p. 807 (1888).

last undivided ray of the dorsal is weak and articulated. The lips of *S. nashii* are "thin, without any transverse fold across the lower one. Snout in the adult covered by papillae". In this species also the dorsal is without an osseous ray. In *S. brevidorsalis*, there are "three rows of large pores across the snout, and extending on to the preorbital bone ; knob at symphysis badly developed ; a thin cartilaginous covering to both jaws. Upper lip crenulated". The last undivided ray of the dorsal fin is osseous, very strong and entire.

Fortunately, specimens of all the three species are present in the collection of the Indian Museum so I am in a position to give further

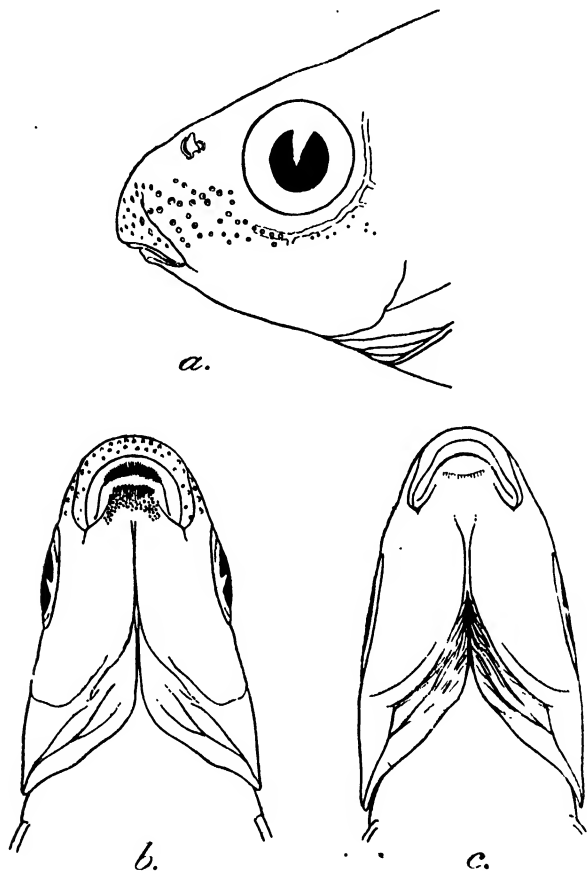


TEXT-FIG. 2.—Species of *Osteochilus* Günther from Peninsular India : Nat. Size.

a. *Osteochilus* (*Osteochilichthys*) *thomassi* (Day); b. *Osteochilus* (*Osteochilichthys*) *nashii* (Day); c. *Osteochilus* (*Kantaka*) *brevidorsalis* (Day).

details regarding their salient features. Of *Scaphiodon thomassi*, Day had two examples from South Canara. One of these (No. 2192), probably the original of his figure in the *Fishes of India*, is now preserved in the collection of the Indian Museum. I find (text-fig. 1 b) that the lips are continuous and fleshy at the angles of the mouth, the upper lip, the basal and adnate part of which is covered by the rostral fold, has a free and

pendulous portion which is markedly fimbriated. The lower lip is transverse, does not cover the jaw and is attached to it at a short distance behind the mouth, only the lateral portions near the angles of the mouth are free and continuous with the upper lip; it is papillated along its anterior border which is followed by a transverse series of small



TEXT-FIG. 3.—*Osteochilus (Osteochilichthys) nashii* (Day).

*a.* Lateral view of head of the specimen No. F11145/1 from the Bhavani river:  $\times 2$ ; *b.* Ventral surface of head of same:  $\times 2$ ; *c.* Ventral surface of head of a young specimen from Shimoga, Mysore.

pores. There are oblique grooves on the sides of the snout running to the ventral surface which are more marked when the mouth is closed. Other features are as described by Day.

On further examination I find that the specimen from Coorg referred by me<sup>1</sup> to *S. thomassi* belongs to *S. nashii* and that one (No. F 12430/1) of the four specimens with broad mouth and fimbriated lips described by me<sup>2</sup> as *S. nashii* is referable to *S. thomassi* (text-fig. 1 c). The confusion had arisen owing to the fact that in the young of *S. thomassi* also the body is marked with a dark lateral band and the dorsal and anal fins are

<sup>1</sup> Hora, S. L., *Rec. Ind. Mus.* XXXIX, p. 19 (1937).

<sup>2</sup> Hora, S. L., *ibid.*, p. 9 (1937).

marked with dark bands (text-fig. 2 *a* & *b*). In spite of the common colour markings and uniformity in scale-counts and number of fin ray; the two species can readily be distinguished by the structure of the mouth and associated parts and by the greater depth of body in *S. thomassi* ( $3\frac{1}{2}$  in *thomassi* versus 4-5 in *nashii*).

In *S. nashii* the mouth is narrower, the lips are simple and continuous at the angles of the mouth; the portion of the lower lip between the lateral portions of the labial groove is considerably behind the tip of the jaw, to which it is firmly attached, and is plicated. Mukerji<sup>1</sup> redescribed this species from a specimen from the Bhavani River in the Nilgiri Hills. Attention may here be directed to a footnote by Day<sup>2</sup> on variation in the form of the snout in this species. He stated :—

“The mouth in this species alters so with age, that until I had compared specimens of my *Osteochilus Malabaricus* with gradations of *Scaphiodon Nashii* since obtained, I could not have believed in their being identical. In the young the jaws are compressed, each with a cartilaginous covering: the lips at the angles are thick and continuous, not continued across the chin. As age increases the mouth widens, the cartilaginous covering becomes more horny, and the colours of the fish alter.”

It has already been pointed out by Mukerji that Day's *Osteochilus malabaricus* is probably a misnomer as he seems to have described no species under this name. However, one thing is clear that Day regarded a certain fish from Malabar allied to *Osteochilus* Günther. *S. thomassi*, with fimbriated lips, has certainly great affinities with Günther's genus. I shall refer to this later.

*Scaphiodon brevadorsalis* (text-fig. 2 *c*) is readily distinguished from the other two species referred to above in the possession of a strong dorsal spine. In the young stage, the upper lip is feebly but distinctly fimbriated and the lower lip is papillate (text-fig. 4 *b*), but with growth the upper lip becomes crenulated (text-fig. 4 *d*) as described by Day. In the structure of the mouth and the associated parts, this species is more or less intermediate between the other two, and there can be no doubt that the three forms have much in common to be included in a single genus.

As remarked above, Day's species of *Scaphiodon* from the Western Ghats are abundantly distinct from *Cyprinion* Heckel (= *Scaphiodon* Heckel) and somewhat allied to *Osteochilus* Günther. The latter genus was established by Günther<sup>3</sup> to accommodate a group of Cyprinid fishes from the 'East-Indian Archipelago' with the following characteristics :

“Scales rather large. Dorsal fin without osseous ray, with from thirteen to twenty-one rays, commencing in advance of the ventrals. Snout obtusely rounded, maxillary region scarcely thickened, and but slightly projecting beyond the mouth. Mouth transverse, inferior or subinferior, with the lips more or less thickened, fringed or crenulated; instead of the inner fold, as described in *Labeo*, the osseous part of the mandible forms a hard sharp transverse prominence; no symphyseal tubercle. Barbels small, nearly always four. Anal scales not enlarged. Anal fin very short. Pharyngeal teeth 5.4.2—2.4.5.”

“Snout sometimes with horny tubercles which periodically fall off, leaving their former bases as shallow round depressions (pores).”

Day<sup>4</sup> included three species from Burma under *Osteochilus*, but on an examination of the specimens in the collection of the Indian Museum I find that Day's specimens of *O. chalybeatus* (Cuv. & Val.) do not belong

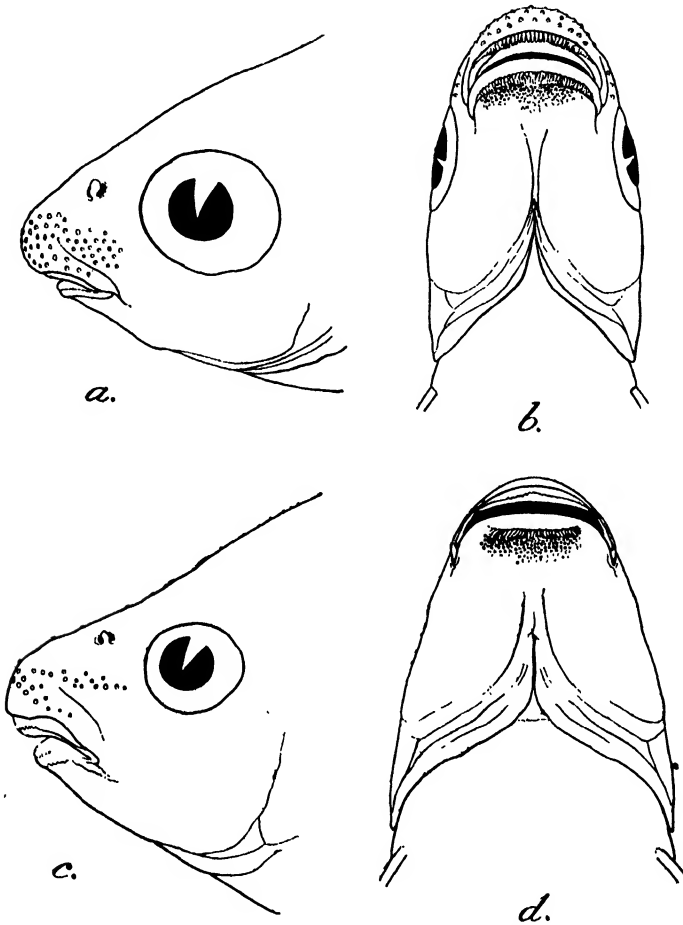
<sup>1</sup> Mukerji, D. D., *Journ. Bombay Nat. Hist. Soc.* XXXV, p. 169 (1931).

<sup>2</sup> Day, F., *Fish. India*, p. 552 (1877).

<sup>3</sup> Günther, A., *Cat. Fish. Brit. Mus.* VII, p. 40 (1868).

<sup>4</sup> Day, F., *Fish. India*, p. 545 (1877).

to this genus, but are referable to *Labeo* Cuvier. In fact, the two specimens of *O. chalybeatus* in the collection (Nos. 1527 and 1528) were,



TEXT-FIG. 4.—*Osteochilus* (*Kantaka*) *brevidorsalis* (Day).

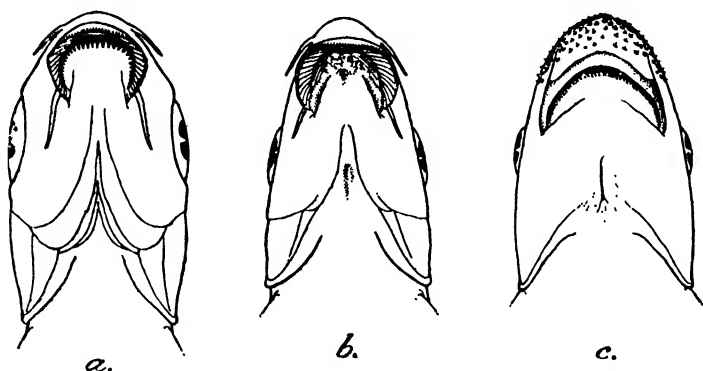
a. Lateral view of head of a young specimen from the Bhavani river:  $\times 2\frac{3}{4}$ ; b. Ventral surface of head of same:  $\times 2\frac{3}{4}$ ; c. Lateral view of head of an adult specimen from Mysore:  $\times 1\frac{1}{2}$ ; d. Ventral surface of head of same:  $\times 1\frac{1}{2}$ .

entered in the Register on 21st May, 1879, as *Labeo*; they had been collected at Moulmein. One of these specimens (No. 1527) is probably the original of Day's description and figure, while the other has only 39 scales along the lateral line and 9 branched rays in the dorsal fin. The snout is covered with large well developed pores. This specimen seems to belong to *Labeo boga* (Hamilton). There are four specimens (Cat. Nos. 667-669) of *Osteochilus neilli* (Day) from Mandalay and Sittang but there is no specimen of *O. cephalus* (Cuv. & Val.). The last species was described by Cuvier and Valenciennes<sup>1</sup> as a *Labeo* and Vinciguerra<sup>2</sup> also showed that it is not referable to *Osteochilus*. It would thus appear

<sup>1</sup> Cuvier, G., and Valenciennes, A., *Hist. Nat. Poiss.* XVI, p. 374 (1842).

<sup>2</sup> Vinciguerra, D., *Ann. Mus. Civ. Stor. Nat. Genova* (2) IX, p. 265 (1890).

that Day had only one species of *Osteochilus* from Burma which is very similar to the large number of species known from the East Indies. Since



TEXT-FIG. 5.—Ventral surface of head and anterior part of body of three species of *Osteochilus* Günther from Burma.

a. *Osteochilus* (*Osteochilus*) *neilli* Day :  $\times 2\frac{1}{2}$  ; b. *Osteochilus* (*Osteochilus*) *vittatus* (Cuv. & Val.) :  $\times 1\frac{1}{2}$  ; c. *Osteochilus* (*Altigena*) *sondhii* Hora and Mukerji :  $\times 1\frac{1}{2}$ .

then Mukerji<sup>1</sup> recorded *O. vittatus* (Cuv. & Val.) from the Mergui District, Lower Burma, and Mukerji and I<sup>2</sup> described *O. sondhii* from the Salween River at Takaw in the Kengtung State, Burma. The last species possesses only two short maxillary barbels and the lips are only slightly fimbriated, but the lower lip, though free, still covers the jaw and is finely striated along its entire inner surface.

In recent years several new species of *Osteochilus*, with considerable variation in structure and form, have been described from Southern China and Siam, and it appears that the genus is widely distributed in south-eastern Asia with its range extending as far west as Burma. Two attempts have been made to group the species into subgenera. Lin<sup>3</sup> in his account of the Chinese species of *Osteochilus* observed that :

"The Chinese species of this genus show some notable variations from those of the Indo-Australian Archipelago and the mainland of India. The small, superior eye, and the striate or smooth upper lip of *O. tungting* and *O. brevis*, for example, are characters not known to be present in Indian species. But variations of this sort are quite common among the closely allied species of *Cyprinidae* and can not be of generic significance. In my description, therefore, I have taken the liberty to add these two characters and other small points to the original diagnosis of *Osteochilus* by Günther."

Lin recognised two sub-genera in the genus *Osteochilus*, which he defined as follows :—

- |  |         |                      |
|--|---------|----------------------|
| A. Eye moderate or large, less than 5 in head ; cheek narrow ; skin of head not thickened. Lips thick, the upper one strongly striate, usually dilated laterally, continuous. Lower lip more or less papillate or fimbriate. Mandibular margin with transverse, hard, sharp, horny sheath. Barbels 4, or 2 maxillary ones only | .. .. . | <i>Osteochilus</i> . |
| AA. Eye small, its diameter more than $5\frac{1}{2}$ in head, immediately below upper profile of head. Cheek deep. Skin of head thickened. Mouth distinctly inferior ; lips thick, papillose, not fimbriate. Mandible with transverse, sharp horny edge. 2 minute maxillary barbels or none                                    | .. .. . | <i>Altigena</i> .    |

<sup>1</sup> Mukerji, D. D., *Rec. Ind. Mus.* XXXIV, p. 286 (1932).

<sup>2</sup> Hora, S. L., and Mukerji, D. D., *Rec. Ind. Mus.* XXXVI, p. 359 (1934).

<sup>3</sup> Lin, S. Y., *Lingnan Sci. Journ.* Canton XII, p. 340 (1933).

Fowler<sup>1</sup> distinguished two subgenera among the species from Siam and the East Indies, *Osteochilus* and *Neorohita*, on the size of scales (small, 45 to 55 in lateral line in *Osteochilus* while moderate or large, 30 to 40 in lateral line in *Neorohita*) and general physiognomy—the eyes being more elevated and snout short in *Neorohita*.

It will be clear from the above that though Day's three species of *Scaphiodon* from the Western Ghats cannot be assigned to *Osteochilus* Günther (*sensu stricto*), they are very closely related to *Altigena* Lin in the structure of the mouth and associated parts though the eyes are relatively much larger. Relying on the number of scales, their position would appear to be among *Neorohita* Fowler, but the structure of the mouth parts is very different. I am, therefore, obliged to separate them from the large number of species that have hitherto been described under *Osteochilus*. For the two species without an osseous ray in the dorsal fin, *Scaphiodon thomassi* and *S. nashii*, I propose the subgenus *Osteochilichthys*; while for the unique species with a strong dorsal spine in the dorsal fin, *S. brevidorsalis*, Kantaka<sup>2</sup>. Of the species of *Osteochilus* known from Burma, *O. neilli* Day, with 34 scales along the lateral line, four barbels, fimbriated lips and eye  $3\frac{1}{2}$  times in length of head is referable to the subgenus *Osteochilus* Lin. *O. vittatus* (Cuv. & Val.), with 33-34 scales along the lateral line, four barbels, fimbriated lips and eye 3-4 times in length of head also pertains to the same subgenus. As regards general physiognomy, however, *O. neilli* is allied to *O. melanopleura* (Bleeker), the type of Fowler's subgenus *Osteochilus*, though its scales are of a moderate size. The third Burmese species, *O. sondhii* possesses 39-40 scales along the lateral line, two short maxillary barbels which are hidden in deep grooves, lips are slightly fimbriated or papillated (the lower lip, though free from the jaw, covers it entirely) and the eye is contained from 3.5—3.9 times in the length of the head. On the number of scales, therefore, all the three Burmese species should be included in the subgenus *Neorohita* Fowler, which is the commonest type in south-eastern Asia. It seems, however, that the species of *Osteochilus* from Southern China, Indo-China, Siam, Malay Peninsula and the Indo-Australian Archipelago are greatly in need of revision and regrouping.

### Genus **Osteochilus** Günther.

#### Subgenus **Osteochilichthys**, nov.

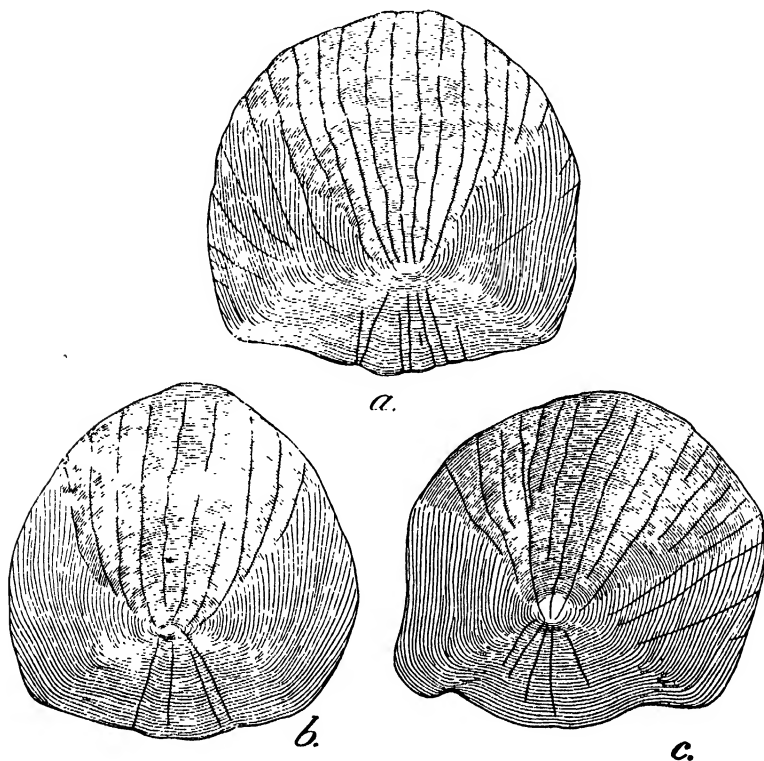
The members of this subgenus differ from the other subgenera of *Osteochilus* in having the lower lip attached to the lower jaw at some distance from the mouth, with the result that the lower jaw is not covered by the lip as is also the case in *Scaphiodon* Heckel. The eye is of a moderate size ( $3-4\frac{1}{3}$  in length of head) and the number of scales along the lateral line varies from 39 to 43.

<sup>1</sup> Fowler, H. W., *Proc. Acad. Nat. Sci. Philad.* LXXXIX, p. 179 (1937).

<sup>2</sup> Derived from a Sanskrit word meaning spine.

*Type-species.*—*Scaphiodon thomassi* Day.

The other species referable to *Osteochilichthys* is *S. nashii* (Day). Though agreeing in lepidosis and number of fin-rays, the two species



TEXT-FIG. 6.—Scales from below base of dorsal fin of species of *Osteochilus* from Peninsular India.

a. *Osteochilus* (*Kantaka*) *brevidorsalis* (Day), young specimen :  $\times 12\frac{1}{2}$ ; b. *Osteochilus* (*Osteochilichthys*) *thomassi* (Day) :  $\times 15$ ; c. *Osteochilus* (*Osteochilichthys*) *nashii* (Day) :  $\times 12\frac{1}{2}$ .

differ in their respective relative depth of the body and the structure of the mouth and associated parts as indicated above.

#### Subgenus <sup>1</sup>**Kantaka**, nov.

This subgenus is proposed for *Scaphiodon brevidorsalis* (Day). It is closely allied to *Osteochilichthys* described above, but differs from it in the possession of a very strong osseous dorsal spine. So far as I am aware, this is the only species of *Osteochilus* in which the dorsal spine is osseous and strong.

*Type-species.*—*Semiplotus brevidorsalis* Day.

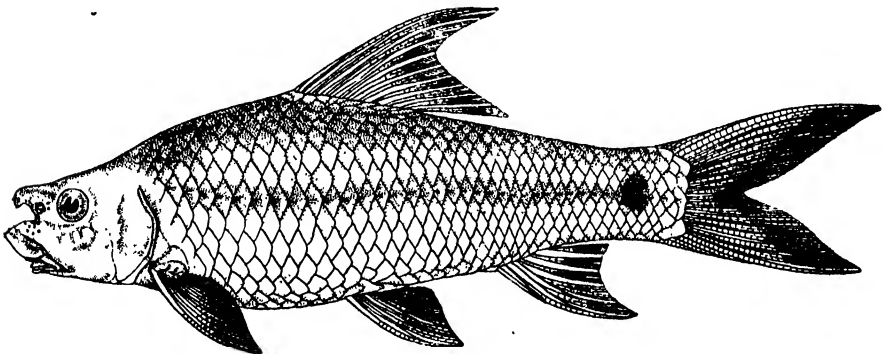


*Measurements in millimetres, scale-counts and fin-rays of Osteochilus (Osteochilichthys) thomassi (Day), O. (Osteochilichthys) nashii (Day) and O. (Kantaka) brevidorsalis (Day).*

	<i>O. thomassi.</i>			<i>O. nashii.</i>				<i>O. brevidorsalis.</i>	
Total length ..	166	143+C.	82	141	104	95	92	264	103
Length of caudal ..	33	—	20	29	23	22	19	63	29
Depth of body ..	47	56	24	35	26	21	20	77	25
Length of head ..	31	33	16	26	19	18	17	43	18
Width of head ..	18	22	10	16	12	11	10	32	11
Height of head ..	26	28	13	19	16	14	14	41	15
Diameter of eye ..	9	10	5	7	6	6	6	11	7
Interorbital distance	12	17	7	11	8	7	7	23	8
Length of caudal peduncle.	19	21	9	18	12	11	12	32	11
Least height of caudal peduncle.	16	20	8	14	10	9	9	26	10
Scales along lateral line	40	39	40	43	41	41	41	40	41
Transverse rows of scales.	13	12	14	14	13	14	14	14	14
No. of predorsal scales	13	13	13	14	13	13	13	12	12
No. of rows of scales between L. 1. and V.	5	4½	5	5	5	5	5	5	5
No. of rays in dorsal ..	4/11	4/11	4/11	4/11	4/11	4/11	4/11	4/12	4/11
No. of rays in pectoral	14	14	14	14	14	14	14	14	14
No. of rays in ventral	9	9	9	9	9	9	9	9	9
No. of rays in anal ..	2/6	3/6	3/6	3/5	3/5	3/6	3/5	3/6	3/5
No. of rays in caudal ..	19	19	19	19	19	19	19	19	19

### XLIII. ON THE SYSTEMATIC POSITION OF *CYPRINUS NUKTA* SYKES.

In describing his *Cyprinus nukta* from the Inderance river, 18 miles north of Poona, Sykes<sup>1</sup> stated that the character of its head—"with

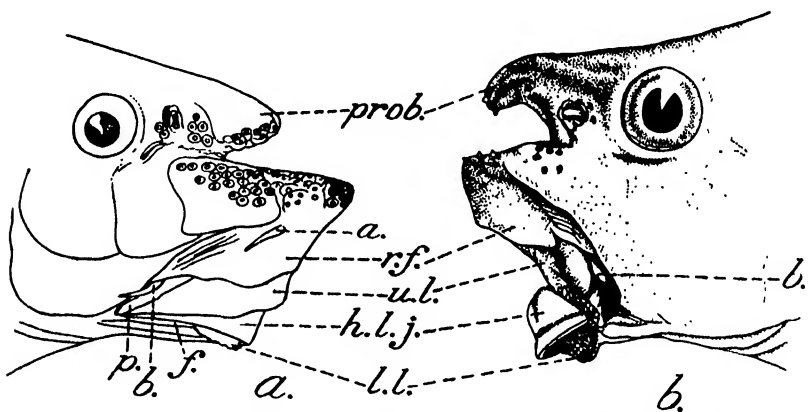


TEXT-FIG. 7.—Lateral view of *Schismatorhynchus (Nukta) nukta* (Sykes) :  $\times \frac{1}{2}$ .

two short horns or bosses on the space between the eyes"—is sufficient to distinguish it from all other species of *Cyprinus*. According to him, both Rüppell and Yarrell, after examining the fish, pronounced it as "a monstrosity of *C. auratus*". Sykes, however, found it very common in the Deccan and the local people recognised it as a distinct kind and called it by the specific name *Nukta*, in which reference is made to the

<sup>1</sup> Sykes, W. H., *Trans. Zool. Soc. London* II, p. 325 (1841).

fist-shaped proboscis on the snout. Jerdon<sup>1</sup> referred to it with a query, but Günther<sup>2</sup> included it definitely under the synonymy of *Carassius auratus*. Day<sup>3</sup> after examining two specimens from Poona, 10 and 12 inches respectively in length, included the species under *Labeo* Cuvier and gave a complete account of the fish. With regard to the structure of the head he observed, "Head compressed, snout projecting over the mouth and having a deep groove passing from one orbit to the opposite one, thus occasioning the appearance as if there were a blunt compressed knob, between and before the orbits". When further material became available to Day<sup>4</sup> from "the rivers of the Deccan", he emended his first description to a certain extent. In the *Fauna* he<sup>5</sup> gave two Marathi names of the species, *Nakta* and *Naktashendva*. A reference to the literature shows that this remarkable character in *Labeo*-like fishes is shared by only one other species, *Schismatorhynchus heterorhynchus* (Bleeker), for which Bleeker<sup>6</sup> had proposed a distinct



TEXT-FIG. 8.—Lateral view of head of two species of *Schismatorhynchus* Bleeker.

a. *Schismatorhynchus* (*Schismatorhynchus*) *heterorhynchus* (Blkr.):  $\times$  Nat. Size. After Weber and de Beaufort; b. *Schismatorhynchus* (*Nakta*) *nukta* (Sykes):  $\times 1\frac{1}{2}$ .

a. rostral barbel; b., maxillary barbel; f., frenulum; h. l. j., horny layer of lower jaw; l. l., lower lip; p., prolongation of the lip; prob., proboscis; r. f., rostral fold; u. l., upper lip.

genus, though Günther<sup>7</sup> and later authors included it under *Tylognathus* Heckel or *Labeo* Cuvier. Weber and de Beaufort<sup>8</sup> have recognised Bleeker's genus as valid and in giving its distribution noted "Fresh water of Indo-Australian Archipelago (Sumatra and Borneo); perhaps also represented on the Indian continent". Presumably the authors had in mind *Labeo nukta* (Sykes), for no other species of *Labeo* on the Indian mainland possesses a proboscis on the snout.

<sup>1</sup> Jerdon, T. C., *Madras Journ. Litt. Sci.* XV, p. 303 (1849).

<sup>2</sup> Günther, A., *Cat. Fish. Brit. Mus.* VII, p. 32 (1868).

<sup>3</sup> Day, F., *Journ. As. Soc. Bengal* XLI, p. 319 (1872).

<sup>4</sup> Day, F., *Fish. India*, p. 543 (1877).

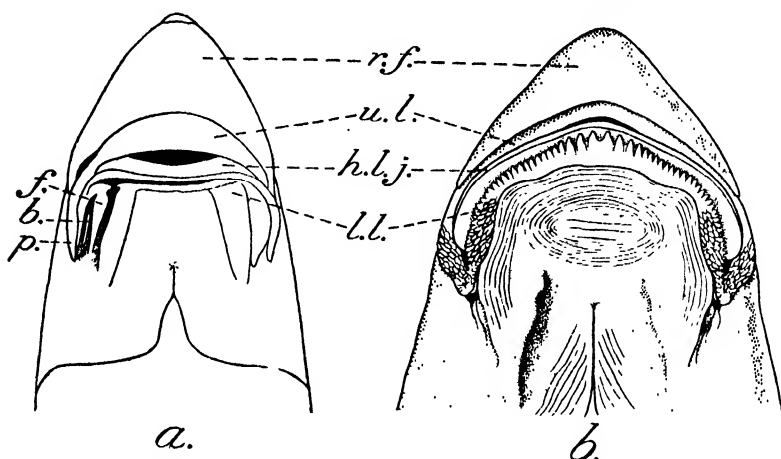
<sup>5</sup> Day, F., *Faun. Brit. Ind. Fish* I, p. 270 (1889).

<sup>6</sup> Bleeker, P., *Nat. Tijdschr. Ned. Ind.* IX, pp. 258, 269 (1855).

<sup>7</sup> Günther, A., *loc. cit.*, p. 67 (1868).

<sup>8</sup> Weber, M. and de Beaufort, L. F., *Fish. Indo-Austral. Archipel.* III, p. 216 (1916).

There is undoubtedly a great similarity between the Indo-Australian species *Schismatorhynchus heterorhynchus* and the Deccan form *Labeo nukta*, but when the specimens of the latter are compared with Weber



TEXT-FIG. 9.—Ventral surface of head in two species of *Schismatorhynchus* Bleeker.

*a.* *Schismatorhynchus* (*Schismatorhynchus*) *heterorhynchus* (Blkr.). Nat. Size, After Weber and de Beaufort; *b.* *Schismatorhynchus* (*Nukta*) *nukta* (Sykes):  $\times 2$ .

*b.*, maxillary barbel; *f.*, frenulum; *h. l. j.*, horny layer of lower jaw; *l. l.*, lower lip; *p.*, prolongation of jaw; *r. f.*, rostral fold; *u. l.*, upper lip.

and de Beaufort's description of the former the following points of difference may be noted :

*Schismatorhynchus heterorhynchus.*

*Labeo nukta.*

- |  |  |
|--|--|
| 1. Lower part of snout much longer and more prominent than the upper.  | Lower part of snout generally longer than the upper, but, though more prominent, may be equal to it.   |
| 2. Corner of mouth prolonged as a kind of gutter.  | Corner of mouth not prolonged.   |
| 3. Lower lip reflected, not continuous with the upper lip.   | Lower lip reflected, inner surface studded with large papillae, continuous with upper lip.   |
| 4. Lower lip separated from the posterior prolongation of the soft covering of the jaw by a longitudinal postlabial groove, which is divided by a longitudinal fleshy frenulum in a median and a lateral part, the last of which contains the maxillary barbel and the gutter-like prolongation. | Labial groove restricted to the corners of the mouth and contains flaplike, crenulated, small maxillary barbels. No longitudinal grooves continuous with the labial groove run backwards from the angles of the mouth. |
| 5. Pair of rostral barbels.  | Rostral barbels absent.  |

The differences noted above in the structure of the lips and associated parts are of sufficient value to separate the two species generically, but I wish at the same time to stress, particularly from a zoogeographical point of view, the great general similarity in the form and structure of the two species and have accordingly divided the genus *Schismatorhynchus* into two subgenera, *Schismatorhynchus* for *S. heterorhynchus*



## ZOOGEOGRAPHICAL REMARKS.

The great significance of the taxonomic findings reported above lies in the fact that further valuable evidence has become available to stress the Malayan affinities<sup>1</sup> of the fish fauna of Peninsular India ; the distribution of *Osteochilus* is at par with that of the Homalopteridae<sup>2</sup>, *Silurus*,<sup>3</sup> *Batasio*,<sup>4</sup> *Thynnichthys*, etc. All of these fishes are widely represented in the fauna of south-eastern Asia, but a few forms are also found in Peninsular India in the Western Ghats or the hill ranges associated with them. The distribution of *Schismatorhynchus* is still more remarkable ; it is represented by one species in Sumatra and Borneo, Malay Archipelago, and by a second species, subgenerically distinct, in Peninsular India. It is remarkable that though a number of the Malayan Cyprinoid genera have undergone structural changes as a result of their long isolation in Peninsular India and have proliferated into new genera or subgenera the typically Malayan catfishes of Peninsular India, such as *Silurus* and *Batasio*, have not shown any marked change from their respective ancestral stock in the Far East.

<sup>1</sup> Hora, S. L. and Law, N. C., *Rec. Ind. Mus.* XLIII, p. 242 (1941).

<sup>2</sup> Hora, S. L., *Rec. Ind. Mus.* XLIII, p. 222 (1941).

<sup>3</sup> Bhimachar, B. S. and Subba Rau, A., *Journ. Mysore Univ.* (B) I, p. 147 (1941).

<sup>4</sup> Hora, S. L. and Law, N. C., *loc. cit.* XLIII, p. 28 (1941).

# CYCLOPOÏDES NOUVEAUX DU CONTINENT INDO-IRANIEN. III-IV.

Par KNUT LINDBERG.

## III.

### **Cyclops kozminskii**, sp. nov.

*Description.* -Longueur sans soies apicales 1164  $\mu$  ; céphalothorax 765  $\mu$ , queue (abdomen+furca) 399  $\mu$ . La largeur maximum, de 418  $\mu$ , se trouve un peu en arrière du milieu du premier segment céphalothoracique. La largeur des 4 autres segments thoraciques est la suivante : 371, 314, 266, 219  $\mu$ . Les angles latéraux des bords postérieurs du deuxième et du troisième segments thoraciques sont légèrement allongés mais ne présentent pas d'élargissements appréciables. Les parties correspondantes du quatrième et du cinquième segments thoraciques montrent une prolongation en pointe dirigée en bas et en dehors, à termination papilliforme tournée légèrement en avant. Il n'y a aucune expansion aliforme de ces parties. La longueur du segment génital surpasse celle des 3 segments abdominaux suivants combinés ; il est un peu plus long que large et se rétrécit graduellement d'avant en arrière. Sa partie proximale est nettement moins large que le cinquième segment thoracique. Bords postérieurs des 3 premiers segments abdominaux grossièrement dentés ; celui du quatrième segment abdominal porte sur la face ventrale une rangée continue de petites épines. Furca à branches légèrement divergentes, environ 6 fois aussi longues que larges, à bords internes ciliés. Longueur : largeur (102+37) : 23=6.04 : 1. La petite encoche pourvue de 1 à 2 épines minuscules se trouve sur le bord externe à 35  $\mu$  de la base de la furca. Soies apicales (du dehors en dedans) 63 : 334 : 464 : 83  $\mu$ . Ainsi la soie apicale interne n'est que légèrement plus longue que la soie apicale externe. La soie latérale externe est insérée un peu en avant de l'union des trois quarts proximaux avec le quart distal. Soie dorsale de 66  $\mu$ , de longueur à peu près égale à celle de la soie apicale externe. Première antenne à 17 articles, assez courte (longueur totale 436  $\mu$ ) ; rabattue, elle atteint à peine le tiers postérieur du premier segment céphalothoracique. La longueur des articles en  $\mu$  est la suivante :

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
83	23	11	35	27	13	32	15	14	15	15	22	15	15	27	32	42

Pattes natatoires tri-articulées. Formule des épines 2-3-3-3. Article terminal de l'endopodite de la quatrième paire de pattes un peu plus de deux fois aussi long que large (longueur : largeur 74 : 34  $\mu$  = 2.18 : 1) ; épines apicales de longueur à peu près égale, l'externe surpassant très légèrement celle de l'interne ; elles sont beaucoup moins longues que l'article (épine interne : épine externe 43 : 45  $\mu$  = 0.96 : 1 ; article : épine interne 74 : 43  $\mu$  = 1.72 : 1). Lamelle basale réunissant la quatrième paire de pattes à petites éminences latérales et à très faible con-

cavité au centre du bord libre. Cinquième patte à deuxième article 2 fois aussi long que large ; épine insérée en arrière du milieu du rebord interne ; soie apicale 2 fois plus longue que la soie externe du premier article (soie du premier article  $53\ \mu$  ; soie apicale  $100\ \mu$  ; épine  $13\ \mu$ ). Réceptacle séminal montrant deux moitiés dissemblables. La partie distale était difficile à distinguer et est représentée sur la figure d'une

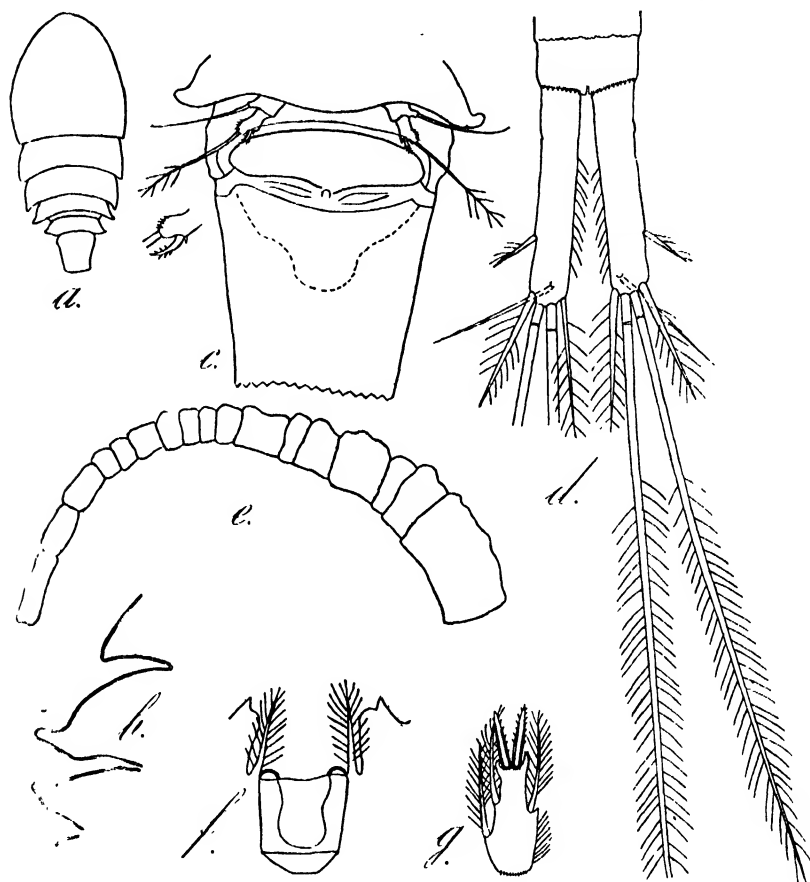


FIG. 1.—*Cyclops kozminskii*, sp. nov. ♀.

a. Céphalothorax et premier segment abdominal. b. Angles latéraux des troisième quatrième et cinquième segments thoraciques. c. Cinquième patte et réceptacle séminal. d. Furca. e. Première antenne. f. Lamelle basale de P 4. g. Article 3 de l'endopodite de P 4.

façon approximative ; la partie proximale par contre était d'une grande netteté ; elle remplissait de ce côté transversalement la plus grande partie du segment génital. Ovisacs très grands, dépassant l'extrémité de la furca ; ils étaient légèrement écartés du corps ; l'un renfermait 27 oeufs, l'autre 31. Mâle inconnu.

*Habitat*.—Une fosse contenant de l'eau de pluie à Lahidjan (Guilan). Une seule femelle pêchée fin octobre 1939. Dans la même fosse se trouvaient d'assez nombreux *C. viridis* Jurine, quelques *C. bicuspidatus* Claus, et une seule *E. serrulatus* Fischer.

*Remarques.*—La forme présente n'a pu être décrite que d'après un seul individu, mais ses caractéristiques sont si définies et si frappantes qu'il n'est possible de la rapprocher d'aucune autre espèce connue jusqu'à maintenant, pour autant que je le sache. Elle offre une structure du réceptacle séminal semblable à celle de *C. insignis* Claus, mais s'en distingue par des différences notables dans la première antenne, la furca et l'article 3 de l'enp. 4. De *C. kolensis* Lilljeborg elle se sépare nettement par la configuration du réceptacle séminal et de l'article 3 du l'enp. 4. Pour autant qu'il me soit connu aucun autre *C. strenuus* s. l. possède un article terminal de l'endopodite de P 4 à épines apicales de longueur à peu près égale.

J'ai nommé cette espèce intéressante et très remarquable en honneur du savant polonais Zygmunt Kozminski, envers lequel tous ceux qui étudient le sous-genre *Cyclops* s. str. ont contracté une dette de reconnaissance durable.

### **Cyclops caspicus, sp. nov.**

A Bender Gaz j'ai trouvé dans trois habitats différents des animaux qui se sont montrés difficiles à classer.

Leur formule des épines était de 2-3-3-3. Les angles latéraux des bords postérieurs des quatrième et cinquième segments thoraciques offraient des prolongements notables avec un certain degré d'élargissement, qui cependant semblait moins prononcé que chez *C. vicinus* Uljanine. Leur segment génital avait vers le milieu une constriction assez brusque, mais, par suite de la structure des angles latéraux des segments thoraciques déjà mentionnés, et des branches de la furca comparativement courtes, il ne m'a pas semblé possible de les identifier avec *C. furcifer* Claus. De *C. vicinus vicinus* ils se différenciaient nettement par le peu de développement de la soie apicale interne de la furca, sa longueur en pour cent de la longueur de la soie apicale externe variant chez les cinq femelles examinées de 112 à 138, avec une moyenne de 122 p. cent. Ceci semblait exclure une comparaison même avec *C. vicinus kikuchii* Smirnov, chez qui ce pourcentage est de 170.9 (selon Kozminski). La longueur des branches de la furca ne s'accordait pas avec celle de *C. vicinus vicinus* et encore moins avec celle de *C. vicinus kikuchii*. La structure de l'article 3 de l'enp. 4 et celle de la cinquième patte ressemblait à celle de *C. furcifer*.

Les faits étant ainsi il ne m'a été possible de traiter ces spécimens comme appartenant à une sous-espèce ni de *C. vicinus* ni de *C. furcifer*, et je n'ai pas vu d'autre solution que de les considérer comme représentant une espèce nouvelle pour la science.

*Description.*—Femelle, 5 individus examinés (spécimens ayant la première antenne à 14 articles 3 ; à 16 et à 17 articles une de chaque). Longueur sans soies apicales de 1500 à 1786  $\mu$  ; largeur de 522 à 570  $\mu$ . Habitus général assez élancé ; angles latéraux des bords postérieurs des deuxième et troisième segments thoraciques sans expansions ou accentuations appréciables ; ceux des quatrième et cinquième segments notablement allongés en pointe, tournée en dehors et un peu en avant. Segment génital à peu près aussi large que long. Sa partie proximale est renflée et elle se rétrécit assez subitement en arrière, la partie distale offrant



un aspect cylindrique. Bords postérieurs des trois premiers segments abdominaux grossièrement dentés. Le quatrième segment abdominal

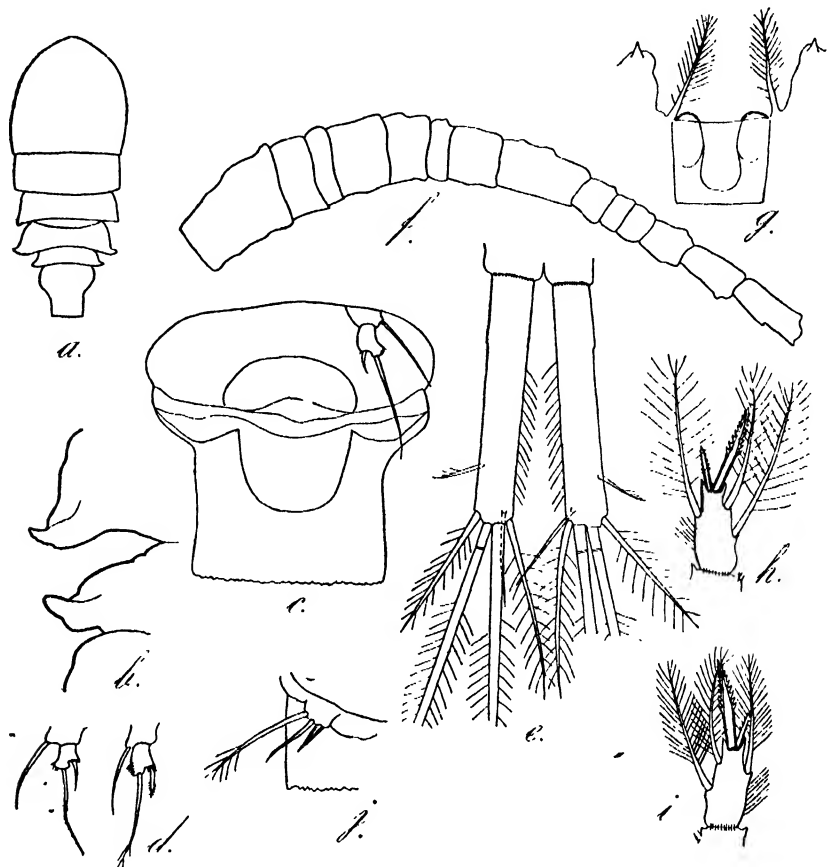


FIG. 2.—*Cyclops cuspidus*, sp. nov. (Marais au bord de la mer).

a. ♀ Céphalothorax et premier segment abdominal. b. ♀ Angles latéraux des quatrième et cinquième segments thoraciques. c. ♀ Réceptacle séminal. d. ♀ Cinquième patte (deux individus). e. ♀ Furca. f. ♀ Première antenne. g. ♀ Lamelle basale de P 4. h. ♀ Article 3 de l'endopodite de P 4. i. ♀ Article 3 de l'endopodite de P 4. (autre spécimen). j. ♂ P 6.

porte sur sa face ventrale une rangée d'épines minuscules. Furca, à branches d'environ 6 fois aussi longues que larges, le plus souvent légèrement divergentes ou parallèles ; chez un spécimen à première antenne composée de 17 articles, de même que chez celui comptant 16 articles de cette antenne, elles étaient fortement divergentes ; leur bord interne porte des cils et sur la face dorsale se voit une crête chitineuse. Le bord externe présente vers le tiers proximal une petite entaille ou protubérance. Soie latérale externe à insertion dorsale, à la jonction des quatre cinquièmes proximaux avec le dernier cinquième distal. Soie dorsale plus courte que la soie apicale externe. Soie apicale interne un peu plus longue que la soie apicale externe. Soie apicale médiane interne plus de deux fois aussi longue que la branche de la furca. Première antenne à 14, 16 ou 17 articles ; rabattue, elle atteint le plus sou-

vent le bord postérieur du premier segment céphalothoracique et parfois le milieu du deuxième segment thoracique. La longueur des articles de la première antenne était la suivante chez la femelle à 14 articles la plus grande :

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
100	31	17	48	35	18	43	80	28	20	22	40	53	60 $\mu$ .

La longueur respective des articles de l'individu dont la première antenne en comptait 16 est donnée ci-dessous :

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
108	27	17	47	33	18	47	40	22	25	30	17	25	43	58	68 $\mu$ .

Ainsi la longueur totale de 625  $\mu$  représentait 478 pour mille de la longueur du corps (prise dans le sens de Kozminski, c'est-à-dire céphalo-thorax+abdomen sans furca).

Les deux branches des pattes natatoires à 3 articles. Formule des épines 2-3-3-3. Article terminal de l'enp. 4 deux fois ou un peu moins que 2 fois aussi long que large. Epine apicale interne surpassant considérablement la longueur de l'article ; elle est plus de deux fois et peut même être presque trois fois aussi longue que l'épine apicale externe.

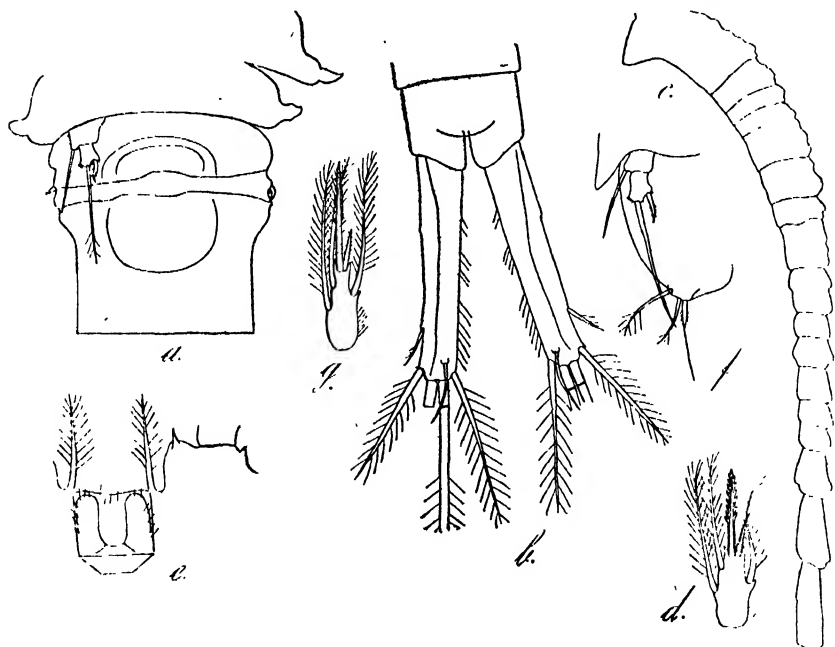


FIG. 3.—*Cyclops caspicus*, sp. nov. (Mare près de la voie ferrée).

a. ♀ Angles latéraux des segments thoraciques 4 et 5, segment génital et P 5. b. ♀ Furca. c. ♀ Première antenne. d. ♀ Article 3 de l'enp. 4. e. ♀ Lamelle basale de P 4. f. ♂ P 5 et P 6. g. ♂ Article 3 de l'enp. 4.

Lamelle basale de la quatrième paire de pattes offrant la structure usuelle des membres du groupe *strenuus*. Cinquième patte à deuxième article trapu, à épine du rebord interne prenant son origine près de

*Cyclops caspicus*, sp. nov.

Habitat.	Longueur $\mu$	Furca.	Sole dorsale.	Soles apicales.	Exp. 4. Art. 3. Long. : larg.	Exp. 4. Art. 3. Ep. ap. int. : ép. ap. ext.	Exp. 4. Long. art. 3 : ép. ap. int.	P 6 Epine : sole méd : sole ext.	Première antenne. Nombre d'articles.
Marais au bord de la mer.	♀ 1786	(154+40) : 32=6.06 : 1	75	112 : 384 : 461 : 155	67 : 34=1.97 : 1	78 : 30=2.60 : 1	0.86 : 1	...	14
	♀ 1601	(150+40) : 30=6.33 : 1	75	120 : 406 : 501 : 150	67 : 33=2.03 : 1	70 : 32=2.19 : 1	0.96 : 1	...	14
	♀ 1734	(170+42) : 35=6.06 : 1	72	128 : 381 : 476 : 144	62 : 38=1.65 : 1	88 : 30=2.93 : 1	0.70 : 1	...	14
	♂ 1283	(115+33) : 27=5.48 : 1	92	103 : 300 : 401 : 123	62 : 31=2.1	95 : 30=3.17 : 1	0.45 : 1	28 : 50 : 68	...
	♂ 1188	.....	...	.....	...	...	...	30 : 50 : 75	...
Mare près de la voie fermée.	♂ 1235	(110+33) : 27=5.29 : 1	97	102 : x : x : 140	63 : 30=2.10 : 1	95 : 27=3.52 : 1	0.66 : 1	28 : 47 : 87	...
	♀ 1501	(153+41) : 31=6.26 : 1	55	113 : x : 518 : 133	68 : 33=2.06 : 1	82 : 33=2.48 : 1	0.83 : 1	...	16
Marécage entre la ville et la mer.	♂ 1421	(110+37) : 30=4.90 : 1	83	107 : x : x : 133	68 : 30=2.27 : 1	97 : 37=2.62 : 1	0.70 : 1	28 : 50 : 67	...
	♀ 1596	(155+43) : 32=6.19 : 1	73	133 : 401 : 551 : 155	70 : 37=1.89 : 1	83 : 40=2.07 : 1	0.84 : 1	...	17

l'extrémité de l'article. Réceptacle séminal de configuration semblable à celui de *C. strenuus* s. str. Ovisacs grands, pouvant dépasser l'extrémité de la furca, légèrement écartés du corps. J' ai compté de 33 à 62 oeufs dans un ovisac.

Mâle. Longueur sans soies apicales de 1188 à 1421  $\mu$  ; largeur de 332 à 375  $\mu$ . Furca à branches parallèles ou légèrement divergentes. Sixième patte rudimentaire composée d'une épine ventrale forte mais courte, d'une soie médiane plus longue et d'une soie dorso-externe qui est l'appendice le plus long.

*Habitat*.—Bender Gaz, port de mer du département du Gorgan (Asterabad) : (1) Marais près du bord de la mer, 2 ♂♂ et quelques ♀♀ à première antenne à 14 articles. (2) Mare d'eau de pluie près de la voie ferrée, 1 ♂ et 1 ♀ à première antenne à 16 articles. (3) Marécage situé entre la ville et la mer, 1 ♂ et quelques ♀♀ à première antenne à 17 articles.

### **Mesocyclops (Thermocyclops) tinctus** Lindberg.

En 1937 j'ai récolté à Ellora (Etat de Hadéirabad) une femelle unique, qui, en tant qu'il s'agissait d'un animal de provenance indienne, avait un aspect tout à fait inusité. M'ayant semblé avoir l'habitus général d'un petit *C. strenuus*, j'en avais remis l'examen jusqu'au jour qu'il me serait possible d'étudier un matériel suffisant d'autres spécimens du même groupe. En examinant cette année le petit animal en question j'ai à ma surprise trouvé qu'il ne s'agissait d'aucune façon d'un membre du groupe *strenuus*, mais bien d'un *Thermocyclops*, et qu'elle offrait une structure si semblable à celle de l'espèce persane *M. (Th.) tinctus* Lindberg, que je crois nécessaire de l'identifier avec cette forme. Comme le

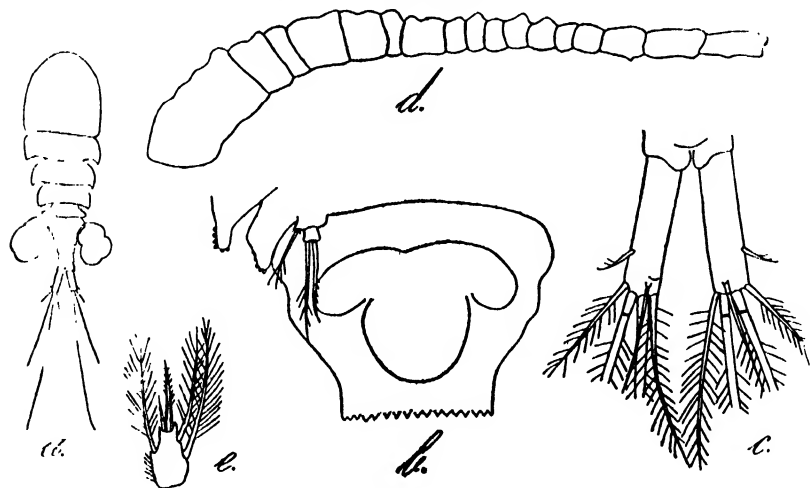


FIG. 4.—*Mesocyclops (Thermocyclops) tinctus* Lindberg ♀.

a. Configuration générale. b. Segment génital c. Furca. d. Première antenne. c. Article 3 de l'endopodite de P 4.

*M. (Th.) tinctus* n'a jamais été rapporté de l'Inde, il semble intéressant de donner ici quelques mensurations et des figures de l'animal d'Ellora. Elle a été pêchée au mois de décembre dans une des citernes des grottes

de cette localité et il convient de rappeler qu'en Iran j'ai trouvé cette espèce plusieurs fois dans des habitats de ce même genre.

*Description.*—Longueur 941  $\mu$  (céphalothorax 675, queue 266  $\mu$ ); largeur 333  $\mu$ . Ailes latérales des bords postérieurs des quatrième et cinquième segments thoraciques pourvues de petites excroissances irrégulières. Branches de la furca divergentes, à bord interne glabre. Longueur: largeur (71+32): 27 $\mu$ = 3.81: 1. Soie dorsale 80  $\mu$ . Soies apicales: 83: 267: 367: 122 $\mu$ . Première antenne à 17 articles; rabattue elle atteignait le milieu du deuxième segment thoracique. Article terminal de l'emp. 4, longueur: largeur 37: 26  $\mu$ =1.42: 1; épine apicale interne: épine apicale externe 53: 27  $\mu$ =1.96: 1. Lamelle basale réunissant la quatrième paire de pattes munie de chaque côté d'une éminence arrondie portant quelques petites épines. Cinquième patte et réceptacle séminal semblables aux parties correspondantes des animaux de l'Iran. Ovisacs petits, écartés du corps; ils contenaient chacun 4 oeufs.

## IV.

**Cyclops (Microcyclops) richardi, sp. nov.**

*Description.*—Petite espèce. Longueur (sans soies apicales) 622 et 646  $\mu$ ; largeur 228  $\mu$  (céphalothorax 399  $\mu$ , queue 223  $\mu$  de l'une des femelles). Segment génital considérablement plus long que large. Bord postérieur des trois premiers segments abdominaux sans découpeure; celui du quatrième segment abdominal porte sur sa face ventrale une rangée d'épines assez grosses. Furca courte, à branches parallèles,

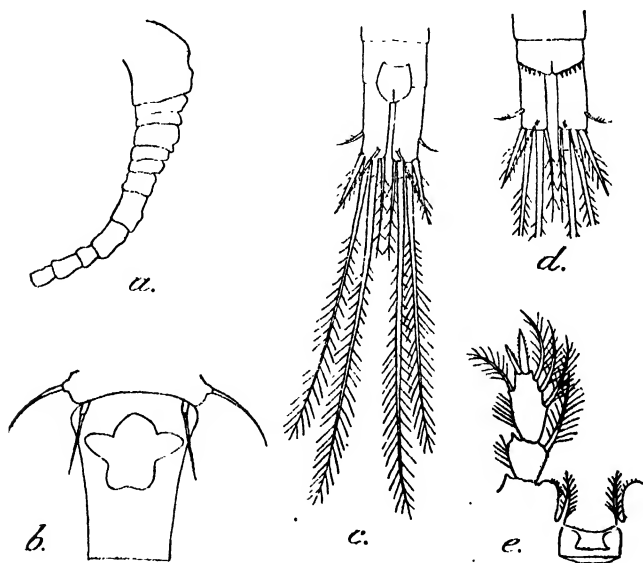


FIG. 5.—*Cyclops (Microcyclops) richardi*, sp. nov. ♀.

a. Première antenne; b. P 5 et segment génital; c. Furca, face dorsale; d. Furca, face ventrale (autre spécimen); e. Lamelle basale et endopodite de P 4.

environ 2 et demi fois aussi longues que larges. Soie latérale externe divisant la branche de la furca dans la proportion d'environ 70 à 30.

Soie apicale interne dépassant en longueur celle de la soie apicale externe (63 : 43  $\mu$  = 1.46 : 1 ; 67 : 42  $\mu$  = 1.59 : 1). Pennation des soies médianes légèrement hétéronyme. Première antenne courte, à 12 articles ; rabattue elle atteint ou dépasse légèrement le milieu du premier segment céphalothoracique. Pattes natatoires à branches bi-articulées ; formule des épines 3-4-4-3. Article terminal de l'endopodite de P 4 un peu moins de deux fois aussi long que large. Epine apicale interne légèrement plus longue que l'épine apicale externe, mais considérablement plus courte que l'article. Cinquième patte se réduisant à un article peu allongé, dépourvu d'épine et portant une soie ciliée. Soie thoracique assez forte. Réceptacle séminal représenté sur la figure d'une façon approximative. Les animaux ne portaient pas de sacs ovigères. Mâle inconnu.

Longueur. $\mu$ .	Furca Long : larg.	Furca Sole dors.	Furca Soies apicales.	Enp. 4. Art. 2. Long. : larg.	Enp. 4. Art. 2 Ep. ap. int. : ép. ap. ext.	Enp. 4 Long : art. 2 : ép. ap. int.
622	(32 + 14) : 19-2.42 : 1	42	43 : 104 : 247 : 63	52 : 27 = 1.93 : 1	33 : 25 = 1.32 : 1	1.58 : 1
646	(33 + 14) : 17-2.76 : 1	53	42 : 204 : 255 : 67	48 : 25 = 1.92 : 1	33 : 26 = 1.27 : 1	1.45 : 1

*Habitat*.—Une fosse d'eau douce à Lahidjan (Guilan). Deux femelles adultes seulement furent récoltées fin octobre 1939.

*Remarques*.—Les traits caractéristiques de cette espèce intéressante sont sa petite taille ; un segment génital allongé, à réceptacle séminal du type *varicans* ; une furca courte, à branches parallèles ; la première antenne de longueur très réduite, composée de 12 articles ; un article terminal de l'endopodite de P 4 à épines apicales assez courtes et offrant peu de différence de longueur entre elles. Pour autant qu'il me soit connu on ne peut rapprocher cette forme d'aucune de celles déjà décrites, et par conséquent elle est présentée comme une espèce nouvelle. Je l'ai nommée en souvenir de J. Richard.

### **Cyclops (Microcyclops) bicolor Sars.**

Pour autant que je le sache *C. (M.) bicolor* n'a été rapporté de l'Inde que par Sewell, qui l'avait trouvé en 1924 au voisinage du lac Tchilka sur la côte nord-est de la péninsule. Dans l'Iran il a été pêché par le Dr. Buxton à Pahlévi en 1921, et par le Dr. Tarnogradsky dans ce même port en 1928 (identifications de Gurney et de Rylov). Au cours de mes récoltes assez nombreuses en Iran j'ai eu l'impression qu'il doit y être rare. En effet je ne l'ai trouvé que dans une seule localité et je n'y ai retiré qu'un individu unique, une femelle adulte sans sacs ovigères. Comme elle diffère à certains égards de *C. (M.) bicolor* tel qu'il a été décrit en Europe, quelques notes et des figures semblent nécessaires.

*Description*.—Longueur (sans soies apicales) 731  $\mu$  ; largeur 228  $\mu$ . Angles latéraux du bord postérieur du cinquième segment thoracique régulièrement arrondis. Segment génital plus long que large. Bord postérieur du quatrième segment abdominal portant une rangée de petites épines sur la face ventrale. Furca allongée, à branches parallèles (longueur : largeur (55+17) : 15  $\mu$  = 4.80 : 1). Soie dorsale 33  $\mu$ . Soies

apicales (du dehors au dedans)  $32 : 145 : \times : 70 \mu$ . La soie apicale interne est ainsi un peu plus de deux fois aussi longue que la soie apicale externe.

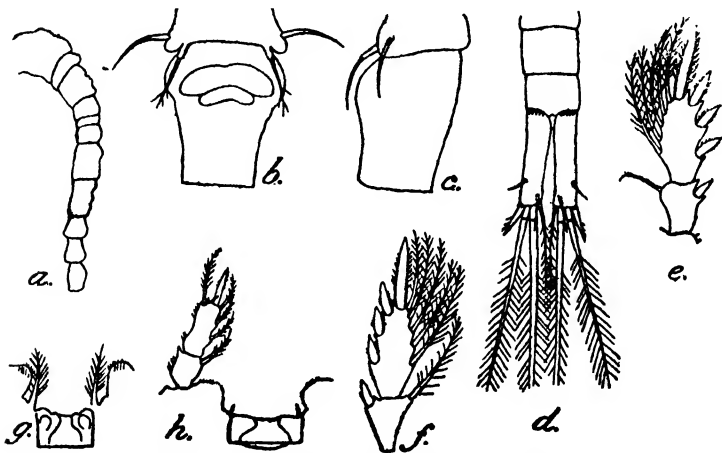


FIG. 6.—*Cyclops (Microcyclops) bicolor* Sars. ♀.

a. Première antenne. b. P 5 et segment génital; c. P 5 et segment génital, face latérale; d. Furca, face ventrale; e. Exopodite de P 2; f. Exopodite de P 3; g. Lamelle basale de P 3; h. Lamelle basale et endopodite de P 4.

Branches des pattes natatoires à deux articles. Formule des épines 3-4-4-3. Epines des exopodites, notamment des P 3 et P 4 fortes, et ayant quelque peu un aspect en lancette. Article 2 de l'enp. 4 un peu plus de 2 fois aussi long que large. Epine apicale interne plus courte que l'article et 3 fois aussi longue que l'épine apicale externe, qui est recourbée en dedans. (Article 2 longueur : largeur  $43 : 19 \mu = 2.26 : 1$ ; épine apicale interne : épine apicale externe  $33 : 11 \mu = 3 : 1$ ; longueur article : épine apicale interne  $1.30 : 1$ .) P 5 formée d'un article très allongé, environ 4 fois plus long que large. Il n'est pas pourvu d'épine et ne montre aucun renflement angulaire de son rebord interne. Réceptacle séminal représenté approximativement sur la figure. Ovisacs pas observés.

*Habitats.*—Inde : Lac Tchilka (Sewell).

Iran : Pahlévi (Gurney et Rylov). Qazvine, bassin d'un caravan-sérail, nov. 1939.

*Remarques.*—Le spécimen récolté est remarquable par l'aspect en lancette des épines, surtout des exopodites de P. 2 et P 3. Une structure semblable s'observe cependant aussi chez certains individus de *C. (M.) linjanticus*, et ne saurait à elle seule justifier la séparation de ces animaux comme appartenant à des variétés distinctes. Du reste l'article de P 5 paraît être d'une longueur insolite chez l'unique exemplaire trouvé dans l'Iran.

### **Cyclops (Microcyclops) moghulensis Lindberg.**

En 1939 j'ai décrit d'après un spécimen unique sous le nom de *C. (M.) moghulensis* un membre du groupe *varicans* ayant la première antenne composée de seulement 10 articles. Dans une seule localité du Sud de l'Iran j'ai trouvé une femelle ressemblant beaucoup à cette espèce, et,

malgré certaines divergences, je me crois justifié à identifier l'animal iranien avec celui des grottes d'Ellora. La différence principale me semble tenir dans le rapport de longueur entre la soie apicale interne et la soie apicale externe de la furca, ces deux soies étant presque de longueur égale chez le spécimen indien, tandis que l'échantillon de l'Iran possède une soie apicale interne considérablement plus longue que la soie apicale externe. La concordance entre les deux animaux est très remarquable en ce qui concerne la structure de la première antenne. Celle-ci n'a que 10 articles distinctes, et chez tous les deux animaux le troisième article présente une division incomplète du côté interne, et le quatrième une ébauche de division sur la partie externe. Je donne ci-dessous quelques notes et des mensurations avec des gravures du spécimen de l'Iran, ainsi que quelques images nouvelles de l'animal de l'Inde pour servir de comparaison.

*Description*.—Longueur 798  $\mu$  (sans soies apicales). Segment génital plus long que large. Bord postérieur du quatrième segment abdominal à rangée de petites épines sur la face ventrale. Furca à branches parallèles, environ 3 fois aussi longues que larges (longueur : largeur,  $(43+30)$  :

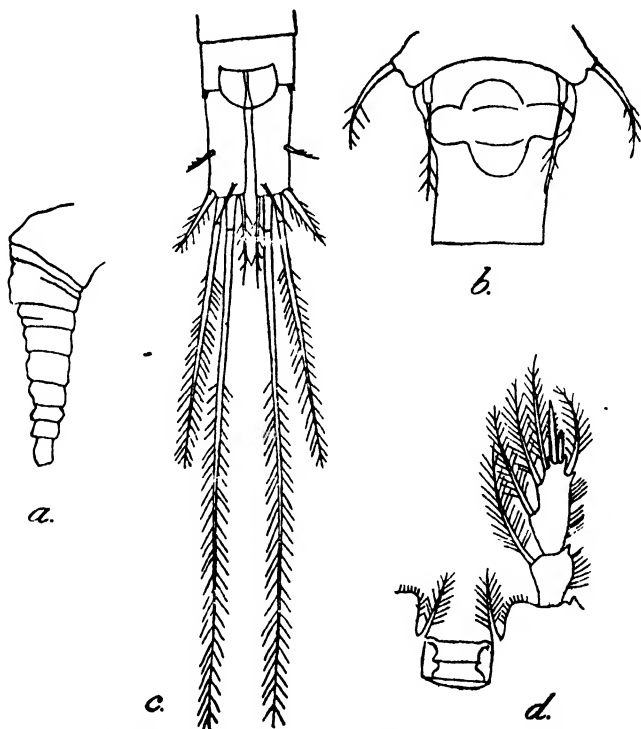


FIG. 7.—*Cyclops (Microcyclops) moghulensis* Lindberg. ♀ (Béhbéhan).

a. Première, antenne; b. P 5 et segment génital; c. Furca, face dorsale; d. Lamelle basale et endopodite de P 4.

25  $\mu$  = 2.92 : 1). Soie dorsale 43  $\mu$ . (Soie dorsale du spécimen d'Ellora 45  $\mu$ ). Soies apicales (du dehors au dedans) 52 : 190 : 361 : 68  $\mu$ . Une mention au sujet de la première antenne a déjà été faite ; elle est remarquablement courte et n'atteint pas le milieu du premier



segment céphalothoracique lorsqu'elle est rabattue. Les articles les plus longs sont les premier, troisième et sixième, et les plus courts, les deuxième et huitième. Article terminal de l'enp. 4 plus de 2 fois aussi long que large ( $67 : 30 \mu = 2.23 : 1$ ). Epine apicale interne un peu moins que 2 fois aussi longue que l'épine apicale externe ( $43 : 24$

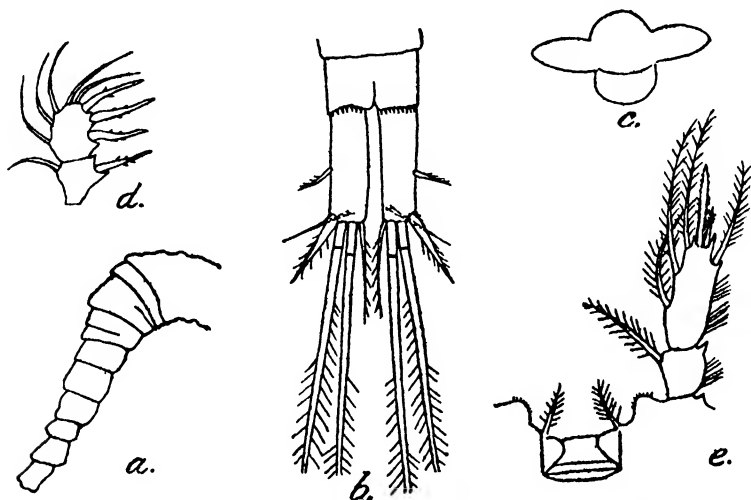


FIG. 8.—*Cyclops (Microcyclops) moghulensis* Lindberg ♀ (Ellora).

a. Première antenne; b. Furca, face ventrale; c. Réceptacle séminal; d. Exopodite de P 1 (montrant fortes épines); e. Lamelle basale et endopodite de P 4.

$\mu = 1.79 : 1$ ). Article terminal de moitié plus long que l'épine apicale interne ( $67 : 43 \mu = 1.56 : 1$ ). Article de P5 environ 3 fois aussi long que large. Il présente une très légère protubérance sur la partie distale du rebord interne, un peu au-delà du milieu de l'article. Longueur de la soie apicale  $67 \mu$ ; longueur de la soie thoracique  $73 \mu$ . L'aspect du réceptacle séminal est montré sur la figure. L'animal manquait de sacs ovigères.

*Habitats.*—Inde : Ellora (Etat de Haïdérabad), citerne naturelle, décembre 1937. Iran : Béhbéhan, un réservoir voûté souterrain, d'eau de pluie. Un seul spécimen récolté en février 1940, avec de nombreux *E. serrulatus* Fischer et quelques *M. leuckarti* Claus.

*Remarques.*—L'animal de l'Inde et celui de l'Iran, dont il a été question dans ses notes, offrent une grande ressemblance avec une forme rapportée par le Dr. Ueno de l'île de Formose et décrite par Kiefer en 1937 sous le nom de *C. (M.) uenoi*. Les deux femelles étudiées par Kiefer possédaient cependant une première antenne formée de 11 articles.

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## THE ORIENTAL TIPULIDAE IN THE COLLECTION OF THE INDIAN MUSEUM. PART II.

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(Contribution from the Entomological Laboratory, Massachusetts State College.)

The preceding part under this general title was published in the *Records of the Indian Museum* XXIX, pp. 167-214, 1927. In the present instalment I wish to continue the study of the extensive series of Tipulidae received during the intervening years through the various authorities in charge of the Zoological Survey of India. My deepest thanks and appreciation are herewith extended to Dr. B. N. Chopra, Dr. Hem Singh Pruthi, Dr. Baini Prashad, Lt.-Col. R. B. S. Sewell and Dr. H. A. Hafiz. It is the friendly interest of these men, and of the entomologists of the Indian Museum, that has so advanced our knowledge of this neglected group of flies in British India. The types and uniques will be returned to the Indian Museum; besides these materials, I have included two species received from other sources, but paratypes of both of these will be added to the Museum collection.

During the course of the past several years I have been particularly privileged to have had sent to me in America the type-specimens of certain of the Brunetti Tipulidae whose strict identity remained in question. Most of such as are discussed in the present paper belong to the vast genus *Tipula* and particularly to those species having marmorate wings, considered by Brunetti to be very closely inter-related and to be virtually unkeyable but now known to belong to sections and subgenera different from one another and all clearly definable. In the present paper, re-descriptions of several of these doubtful species are given, these including *Tipula* (*Acutipula*) *princeps* Brunetti, *T.* (*Vestiplex*) *himalayensis* Brunetti, *T.* (*V.*) *quasimarmoratipennis* Brunetti, *T.* (*V.*) *subtincta* Brunetti, *T.* (*Sinotipula*) *tessellatipennis* Brunetti, *T.* (*Oreomyza*) *striatipennis* Brunetti and *T.* (*Lunatipula*) *marmoratipennis* Brunetti.

### PREOCCUPIED NAMES.

A considerable number of names in Tipulidae have been found to be pre-occupied by earlier names in the same genus and substitutes for such homonyms are proposed herewith. My thanks are due to Dr. Alan Stone, of the United States National Museum, for calling to my attention certain of these preoccupied names.

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#### ENRICO BRUNETTI AND FRED. WALLACE EDWARDS.

The death of Frederick Wallace Edwards on November 15, 1940, at the untimely age of 51, was an incalculable loss to Dipterology. This sad occurrence recalls to mind some of the relations that existed between Edwards and the foremost worker on the Indian Diptera, the late Enrico Brunetti.

As has been indicated by the Director, Dr. Bains Prashad and Dr. Ronald Senior-White in their joint obituary account of Brunetti (*Rec. Ind. Mus.* XXIX, pp. 287-296, 1927), this pioneer worker on the Dipterous fauna of British India, from the date of his first arrival in India in 1904 until his permanent removal from the country in May 1921, had worked at the Indian Museum for irregular periods only and very much of his work at the Museum had been gratuitous. As a partial result, the extensive collections that were made by Brunetti himself were, in some cases, the property of the Museum but in many other instances became the personal property of Brunetti and these latter were eventually bequeathed by him to the British Museum (Natural History), London. The end result of this arrangement was that a considerable proportion of the Brunetti types are preserved in the Indian Museum while the somewhat comparable balance is in London.

The difficulties under which Brunetti worked while in India have been detailed by others. It is certain that his work was of a pioneer nature and that vast chaos existed when he first began his investigation of the Indian Dipterous fauna in 1904. Certain of Brunetti's works are models of study and application, as for example, his "Catalogue of Oriental and South Asiatic Nemocera", *Rec. Ind. Mus.* XVII, pp. 1-300, 1920. As concerns his strictly taxonomic work, however, the fact cannot be ignored that throughout his work on the Tipulidae, at least, a considerable number of partly incredible errors have crept in and many of the assignments of species to genera are entirely erroneous. It is here that the almost incredibly accurate taxonomic eye of Edwards came in to unravel what otherwise must have become an almost unsolvable mystery. In a letter from Edwards to the writer, dated February 16, 1923, he writes: "For the last week or so I have been working with Brunetti at his Tip. types. There have been a good

many disappointments, because in very many cases it is not the actual types which he has brought, but only specimens from his series, and as these were picked out and labelled hastily, it is evident he has made a lot of mistakes in determining his own species. Many of those he has brought do not agree with his descriptions, as he himself admits when I point it out to him. Still he has brought quite a large number of the actual types and we have been able to get a great deal of useful information from them. One surprise to both of us was that in three cases he had omitted to notice that a species possessed white tarsi, and other serious omissions in his descriptions are frequent. Many of his generic references are utterly and sometimes unaccountably wrong. I shall try to get him to write up the results of this critical study when we have finished. It would be rather a tall order for me to make so many corrections of someone else's work and I think he ought to do it himself as a penance."

It is certain that of all persons who have ever concerned themselves with the Oriental Tipulidae, Edwards possessed the fullest knowledge of the subject. His placing in synonymy of many of the Brunetti species may strike some as being drastic but it should never be lost sight of that combined with his unparalleled knowledge of the group, he was the only student who had such an opportunity to see so many of Brunetti's actual types and authentically named specimens. The fact that part of these types are in Calcutta and part in London has made it virtually impossible for any other worker to examine all of this material. Edwards' treatment of the Oriental Tipulidae and his systematic arrangement of the species, with his synonymy, should be followed by all future workers and it seems to the present writer that if errors have crept into this revisional work, such must be few and far between.

In concluding these brief remarks concerning some of the relations existing between Edwards and Brunetti, one further point of interest may be noted. Edwards joined the staff of the British Museum (Natural History) on November 24, 1910. It was shortly before this date that he became engaged to be married (to Miss Florence Mary Williams, of Shelford, Cambridge) and, almost coincidentally, was offered an appointment as Entomologist to the Indian Museum, a position later filled by Dr. Stanley W. Kemp. Family objections to his moving to India caused Edwards to give up the idea. One cannot but wonder what the present status of our knowledge of the Diptera of British India might have been had Edwards removed to India in 1910 and devoted his remaining years and unsurpassed talents to a study of the subject.

#### Subfamily *TIPULINAE*.

#### ***Ctenacroscelis dravidicus* Edwards.**

1932. *Ctenacroscelis dravidicus*, Edwards, *Stylops* I, p. 146.

The type, 1 ♀ was from Kodaikanal, Shola, in the Palni Hills, September 15, 1921 (T. B. Fletcher). One further female in the Indian Museum from the type-locality, altitude 6,700-7,000 feet, August 1922 (S. W. Kemp).

***Ctenacroscelis pallifrons* Edwards.**

1932. *Ctenacroscelis pallifrons*, Edwards, *Stylops* I, p. 147.

The type, 1 ♂ Regd. No. 3973/H1, was from Pashok, Darjiling District, Eastern Himalayas, May 26-June 14, 1916 (F. H. Gravely). One further male from the same locality, Pashok Spur (R. S. Lister).

***Ctenacroscelis dives* (Brunetti).**

1912. *Tipula dives*, Brunetti. *Fauna Brit. India, Dipt. Nemat.*, pp. 307, 368.

The type, a unique ♂ Regd. No. 2394/20, was from Kurseong, June 23, 1910 (N. Annandale). The following re-description of this type is given.

*Male*. —Length about 25 mm.; wing 32.5 mm.

Nasus reduced to a mere stub. Frontal prolongation of head dark liver brown. Antennae apparently only 11-segmented; first flagellar segment long-cylindrical, the second segment about two-thirds this length; fourth to sixth segments with the lower face conspicuously protuberant and densely covered with a microscopic grey pubescence; on the succeeding segments the ventral face is less protuberant but densely pubescent; terminal segment elongate, nearly twice the penultimate, narrowed gradually to the tip, apparently formed of two segments. Head behind greyish, the front and anterior vertex more yellow.

Mesonotal praescutum dark reddish brown, the four dark olive brown stripes narrowly margined by still darker brown, restricting the interspaces to narrow lines; scutum rich brown, each lobe with two olive green areas which have a darker narrow border; scutellum and mediotergite black, heavily pruinose. Dorso-pleural region with a conspicuous orange yellow stripe, beneath which is a broad brown longitudinal stripe that is darkest along the dorsal margin, paling ventrally, the ventral pleurites more olive brown; posterior pleurites and pleurotergite clearer yellow. Legs with the coxae pale, sparsely pruinose, the base of fore coxae narrowly darkened; femora yellow, the tips broadly dark brown; tibiae and first two tarsal segments narrowly tipped with brown; terminal tarsal segments darkened; claws slender, each with a basal lobe or shoulder. Halteres dark brown, the base of stem narrowly yellow. Wings with a strong yellowish brown tinge, the cubital and anal cells somewhat paler; conspicuous darker brown seams along posterior cord,  $Cu_1$ , 2nd  $A_1$ , and somewhat less distinctly on the veins beyond cord. Venation: Vein  $R_1$ , approximately its own length before the fork of  $R_{1+2}$  and  $R_3$ , thus forming a fusion of veins  $R_{1+2+3}$ ;  $R_{1+2}$  straight, slightly furcate at apex in both wings.

Abdomen brownish black, the hypopygium conspicuously paler. Male hypopygium with the ninth tergite long and depressed, the median notch deep and narrow. Outer dististyle nearly smooth, pruinose, broad at base, narrowed to the obtuse apex.



**Ctenacroscelis flavoides** (Brunetti).

1918. *Tipula flavoides*, Brunetti, *Rec. Ind. Mus.* XV, p. 267.

The types, 1 ♂, Regd. No. 3935/H2, 2 ♀♀, Regd. Nos. 3936-37/H2, were from above Tura, Garo Hills, Assam, altitude 3,500-3,900 feet, September 1917 (Mrs. S. W. Kemp). The following re-description of the types is given.

*Male*.—Length about 28 mm. ; wing 33 mm.

General colouration of head and thorax deep orange yellow, the praescutal interspaces somewhat darker. Antennae with the scape orange, the pedicel brown; flagellum black; first flagellar segment a little longer than the second, both cylindrical; third flagellar segment a trifle bulging beneath; succeeding segments shorter and conspicuously protuberant on lower face. Legs with femora yellowish brown, the tips darkened; tibiae and tarsi darker brown. Wings relatively long and narrow. Venation about as usual in the genus;  $R_1$  distinctly before fork of  $R_{1+2}$  and  $R_3$ , forming a fusion of  $R_{1+2+3}$ . Abdomen relatively slender, dark velvety brown, including the hypopygium. Male hypopygium as described by Brunetti, the ninth tergite squarely truncated across caudal margin, not at all bilobed, the median area of caudal margin a trifle convex, the edge fringed with long yellow setae. Outer dististyle relatively short and broad, the apex obtuse. One female, a paratype from the type-locality, has the abdomen with beautiful iridescent blue reflexions, especially basally.

**Ctenacroscelis serricornis** (Brunetti).

1912. *Tipula serricornis*, Brunetti, *Fauna Brit. India, Dipt. Nemat.*, pp. 309-310.

1918. *Tipula serricornis*, Brunetti, *Rec. Ind. Mus.* XV, pl. viii, fig. 4.

The types ♂, Regd. No. 2398/20, ♀, Regd. No. 2399/20, were from Naini Tal, Western Himalayas, May and June 1893, originally from the Lucknow Museum, now in the Indian Museum. The following re-description of the types is given.

*Male*.—Length about 24.5 mm. ; wing 29 mm.

*Female*.—Length about 34 mm. ; wing 33 mm.

Frontal prolongation of head relatively long, obscure yellow; nasus long and slender. Antennae with scape and pedicel obscure yellow, the flagellum more brownish yellow; flagellar segments beyond the first strongly serrate, as described and figured by Brunetti, the ventral face of flagellar segments two to ten, inclusive, produced, more evidently so on the basal segments, the outer segments more elongate, with the serrations less evident; terminal segment elongate, simple. Head pale olive; anterior vertex flat but produced cephalad between the antennal bases.

Pronotum obscure orange. Mesonotal praescutum with the stripes greenish grey, each bordered by a slightly paler line, a little more broadly so on the lateral stripes; intermediate stripes separated by a slightly darker capillary vitta; posterior interspaces darker than the remainder of the ground colour. Pleura striped longitudinally with reddish brown

and buffy yellow, the former appearing as a longitudinal stripe extending from the cervical sclerites, crossing the ventral anepisternum onto the pteropleurite where it is much narrower. Legs with the femora brown, the outer half gradually darkened; tibiae and basal segments of tarsi somewhat brighter; femoral comb with slender teeth; tibial spurs slender. Wings with a pale brownish tinge, the small stigma a trifle darker brown; radial vein in the prearcular region greatly incrassated, dark brown. Venation (text-fig. 1b):  $Sc_1$  preserved as a



TEXT-FIG. 1.—*Ctenacroscelis serricornis* (Brunetti), type; a., details of male hypopygium; b., venation.

stout spur that does not reach costa; free tip of  $Sc_2$  long;  $R_1$  with macrotrichia, uniting with  $R_{2+3}$  at the fork; vein  $R_{1+2}$  entirely preserved; vein  $R_3$  strongly arcuated, closely approximated to the sinuous  $R_{4+5}$ , strongly narrowing the cell at near midlength; cell  $M_1$  sessile or extremely short-petiolate; cell 1st  $M_2$  correspondingly large,  $m$  being long and oblique.

Abdomen with the basal segments relatively bright fulvous orange, the basal tergite and extreme base of the second with a brown sublat-eral stripe; subterminal segments (segments seven to nine, with the caudal half of six) dark brown, pruinose; sternites similar, less darkened outwardly, the median region pruinose. Male hypopygium not incrassated, relatively short. Ninth tergite (text-fig. 1a, 9t) short, the caudal margin with a broad flattened lobe on either side, the apices obliquely obtuse, the median notch very narrow; lateral lobes densely provided with short adpressed brown setae. Basistyle and sternite produced caudad beyond the level of the tergite, as in the genus. Outer dististyle flattened, broadest at the base, gradually narrowed to the obtuse tip. Ninth sternite with a very acute V-shaped notch, the margins sparsely fringed with short setae. Eighth sternite unarmed.

*Female*. Generally similar to the male. Antennae with flagellar segments similarly produced but the serrations a little less distinct. Praescutal stripes darker olive brown. Ovipositor with the valves of moderate length only, the tergal valves slender, straight; sternal valves flattened, their tips acute.

The flagellar pectinations are more accentuated than in most other species of *Ctenacroscelis* but in other respects the species conforms well to the essential characters of the genus.

**Tipula (Sinotipula) tessellatipennis** Brunetti.

1912. *Tipula tessellatipennis*, Brunetti, *Fauna Brit. India, Dipt. Nemat.*, pp. 317, 318, pl. v, fig. 12 (wing).

The types ♂, Regd. No. 2423/20, ♀, Regd. No. 2424/20, were from Naini Tal, Kumaon, Western Himalayas, May and June 1893, originally from the Lucknow Museum, now in the Indian Museum. The following re-description of the types is given.

*Male*.—Length about 17 mm. ; wing 19 mm.

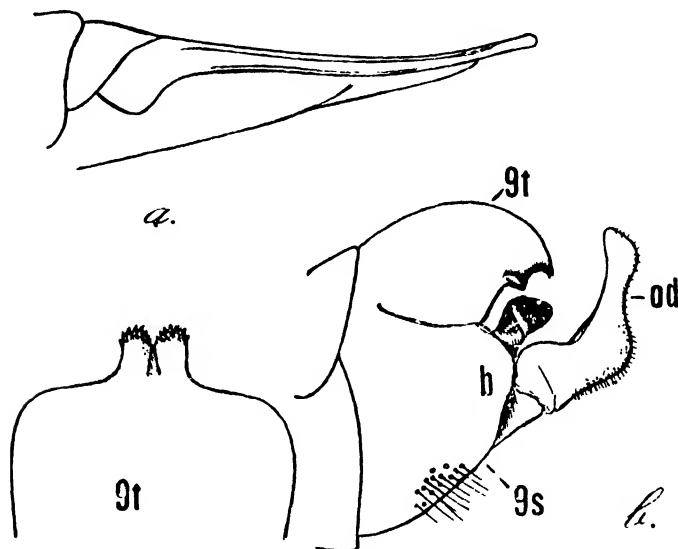
*Female*.—Length about 25 mm. ; wing 22 mm.

*Male*. Frontal prolongation of head elongate, pale brownish ochreous ; nasus short and stout ; palpi dark brown. Antennae short, if bent backward scarcely attaining the wing-root ; scape and pedicel yellow, flagellum obscure yellow, the basal enlargements of the segments dark brown ; flagellar segments with basal enlargement of moderate size, the remainder of segments cylindrical or nearly so, not incised ; each segment with about three elongate verticils on dorsal surface and two very short stout ones on ventral face. Head pale grey, with a relatively broad, pale brown, median vitta, a little expanded in front on the low vertical tubercle.

Mesonotal praescutum clear light grey, with four brown stripes, the intermediate pair more olive brown, almost confluent, separated only by their narrow darker brown margins ; all praescutal stripes bordered by darker brown ; lateral stripes with the mesal border very broad, including approximately one-half the entire width of stripe ; besides the four primary stripes, the grey ground colour is invaded by paler brown areas that include the centres of the interspaces, the humeral region and the broad lateral borders ; the clear grey ground is thus restricted to narrow borders to the darker stripes ; scutum light grey, each lobe with olive brown areas, the larger one behind ; scutellum brown, pruinose ; mediotergite relatively short, grey, with a conspicuous median brown line that is not mentioned in the original diagnosis. Pleura clear grey, the dorso-pleural membrane more buffy. Halteres relatively short, brown, the knob a little darker, with its base slightly yellow. Legs with the coxae light grey ; femora brownish yellow, the tips rather narrowly but conspicuously dark brown ; tibiae obscure yellow, the tips narrowly dark brown ; basitarsi obscure brownish yellow, soon passing into dark brown, concolorous with remainder of tarsi. Wings pale brown, tessellated with darker brown and cream coloured areas, as figured by Brunetti (*loc. cit.*). Venation :  $R_2$  very short ;  $R_{1+2}$  very pale, entirely without macrotrichia, not more than two-thirds as long as  $R_1$ .

Abdominal tergites dark reddish brown, the basal tergites very slightly pruinose ; segments four and five with a blackened median spot ; a broad conspicuous sublateral black line on either side, extending from segment two to the end of segment five, the lateral margins of the segments narrowly buffy ; sternites dark greyish brown, the caudal margins of the segments vaguely more reddish ; subterminal segments, with the hypopygium, reddish brown. Male hypopygium (text-fig. 2b) relatively small, the tergite separate from the sternite except on the cephalic fifth. Ninth tergite, 9t, a transversely subquadrate

plate, gently convex, the caudal margin truncated, with a small cylindrical lobule on either side of the median line, these connate on their



TEXT-FIG. 2.—*Tipula (Sinotipula) tessellatipennis* Brunetti, types : a., ovipositor ; b., details of male hypopygium.

basal halves, the tips free and set with microscopic blackened spicules. Viewed from the side, these submedian lobes are strongly decurved, bifid at tips. Basistyle small. Outer dististyle, *od*, elongate, simple in structure, the basal half stouter, the distal half or less more slender. Inner dististyle very small and simple in structure. Eighth sternite unarmed.

*Female*. Generally similar to the male in most respects. Abdominal tergites one to four obscure yellow, the first a trifle more puinose ; succeeding tergites darker ; all tergites with a broad, darker brown, sublateral stripe, darker brown outwardly, margined abruptly with buffy ; basal sternites orange yellow, the outer segments more greyish. Ovipositor (text-fig. 2a) with the genital shield short and inconspicuous ; tergal valves long and slender, with a basal lobe ; valves gently up-curved, the tips obtuse, margins smooth.

### ***Tipula (Acutipula) princeps* Brunetti.**

1912. *Tipula princeps*, Brunetti, *Fauna Brit. India, Dipt. Nemat.*, pp. 306, 307.

1924. *Tipula princeps*, Edwards, *Rec. Ind. Mus.* XXVI, p. 305.

1932. *Tipula (Acutipula) princeps*, Edwards, *Stylops* I, p. 233.

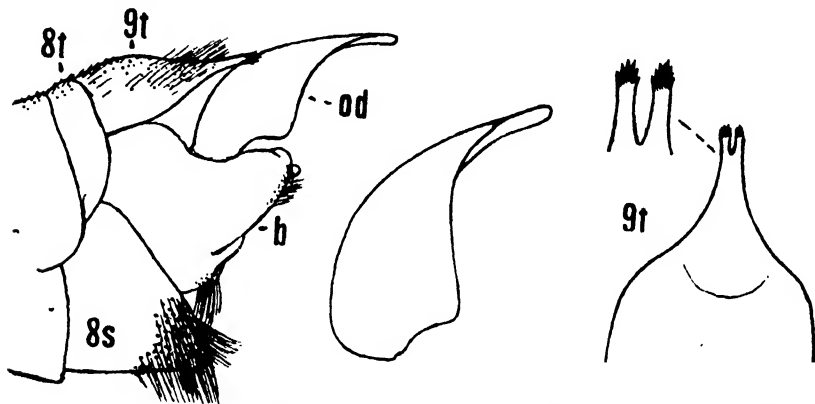
The types ♂, Regd. No. 2392/20, ♀, Regd. No. 2393/20, were from Kurseong, Eastern Himalayas, altitude 4,700-5,000 feet, June 18-19, 1910 (N. Annandale). The following re-description of the types is given.

*Male*.—Length about 24 mm. ; wing 29 mm. Fore-leg, femur, 17.6 mm. ; tibia 20.6 mm. ; tarsus about 45 mm. Middle leg, femur, 19.5 mm. ; tibia 18.6 mm. ; tarsus about 56 mm. Hind leg, femur, 20.5 mm. ; tibia 25.5 mm. ; tarsus about 62 mm.

*Female*.—Length about 35 mm. ; wing 30 mm. ; abdomen 24.5 mm.

Frontal prolongation of head of moderate length, the nasus long and slender. Antennae relatively short ; scape and pedicel brownish yellow ; succeeding segments dark brown with the apices narrowly reddish brown, the outer segments uniformly darkened ; terminal segment only about one-third the length of the penultimate and much more slender. Head brown, the posterior orbits very narrowly pale.

Mesonotal praescutum olive brown with four relatively indistinct reddish brown stripes ; scutum olive brown. Pleura olive, sparsely pollinose. Pronotum and dorsopleural region orange fulvous. Halteres relatively long and slender, dark brown, the base reddish brown. Legs excessively long and slender, as shown by the above measurements ; femora reddish brown, the tips infuscated ; tibiae reddish brown ; tarsi brown, passing into dark brown. Wings pale brown, the base and costal region more yellowish brown ; stigma darker brown ; a paler brown suffusion in the radial cells and as distinct spots in outer end of cell *M* and just before midlength of cell *Cu*.



TEXT-FIG. 3.—*Tipula (Acutipula) princeps* Brunetti; details of male hypopygium of type.

Abdomen reddish brown, the outer segments dark brown ; a narrow dark brown lateral stripe on the tergites, beginning at the base of tergite two, widening behind, on the fifth and succeeding segments becoming confluent with the dark colour of the segment. Male hypopygium (text-fig. 3) with the ninth tergite, *9t*, black, relatively tumid, the caudal margin produced into a flattened median lobe, the distal third or less of which is divided into two slender parallel lobes the tips of which are blackened and microscopically spiculose. Outer dististyle, *od*, widely expanded just beyond base, the outer ventral margin produced into a broadly triangular lobe, the style thence narrowed to the slender apex. Ninth sternite with a V-shaped notch in which hang two relatively stout dark brown lobes, each bearing at tip a stout brush of reddish yellow setae, these brushes decussate on the median line. Caudal margin of eighth sternite provided with a dense fringe of golden yellow setae, the sublateral ones longer.

Additional records : Eastern Himalayas, Darjiling District ♂, Regd. No. 1038/H1, ♀, Regd. No. 1039/H1, legs incomplete, Soom, June 16, 1914 (F. H. Gravely) ; Rakyong, May 28, 1930 (S. L. Hora).

***Tipula (Vestiplex) mitchelli* Edwards.**

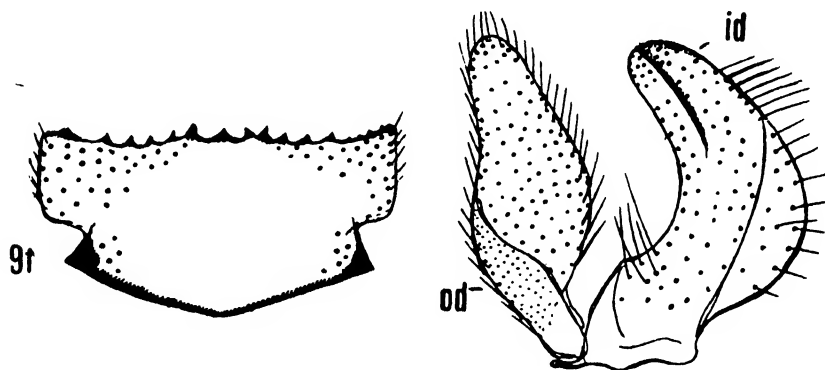
1927. *Tipula mitchelli* Edwards, *Ann. Mag. Nat. Hist.* (9) XX, pp. 229, 230.

Edwards' types were from an unknown station in Kashmir, altitude 11,000-13,000 feet, collected by F. J. Mitchell.

Additional records : Kashmir, Sonamarg, altitude about 9,000 feet, May 17-23, 1921 (Kashmir Survey); Indian Museum. Killanmarg, altitude 10,000 feet, July 19, 1923 (T. B. Fletcher); in writer's collection.

The latter specimen is a metatype received from Edwards and showing the white of the wings even more extensive than in the types, including major parts of cells *R* and *R*<sub>1</sub>, the post-stigmal band wider, and the white areas in cells *M* and 2nd *A* even more extensive.

Male hypopygium (text-fig. 4) with the ninth tergite, *9t*, appearing as a flattened, heavily sclerotized saucer, the caudal margin and cephalic rim narrowly more blackened than the disk; caudal border almost straight but provided with a series of about a dozen denticles, including



TEXT-FIG. 4.—*Tipula (Vestiplex) mitchelli* Edwards; details of male hypopygium

a lower median tooth and five or six sharper teeth on either side, arranged in a descending series from the submedians to the laterals; although there must be considerable variation in these teeth in different individuals, nevertheless the general arrangement as described seems to hold. The setigerous punctures of the lateral portions of the saucer are very distinct. Basistyle not produced into a spine, thus differing from most other Oriental species of the subgenus. Both dististyles relatively small and simple, the outer style, *od*, an elongate-oval pale blade, its setae pale; inner style, *id*, gently arcuated, the obtuse tip more blackened, the outer margin elevated into a high rounded compressed crest, the whole style with abundant scattered setae.

***Tipula (Vestiplex) subreposita*, sp. nov.**

Allied to *reposita*; general colouration of mesonotal praescutum grey, with four dark blackish grey stripes that are not or scarcely margined by darker; antennal scape and pedicel clear yellow, flagellar segments weakly bicoloured; a distinct dark median vitta on vertex; thoracic pleura chiefly yellow, restrictedly variegated with brown;

femora dark brown, the tips blackened, preceded by an obscure yellow subterminal ring; tibiae dark brown; wings with a weak brown ground colour, variegated by cream-coloured areas, including a post-stigmal fascia extending into the base of cell  $M_3$ ;  $Rs$  about two and one-half times  $m-cu$ ; abdominal tergites black, the basal segment more reddish; male hypopygium with the tergite entirely pale, the caudal margin broadly and evenly emarginate, without blackened points; basistyle produced into a very powerful spine; outer dististyle a blackened clavate blade; rostral prolongation of inner dististyle narrow, before apex with an acute spinous point.

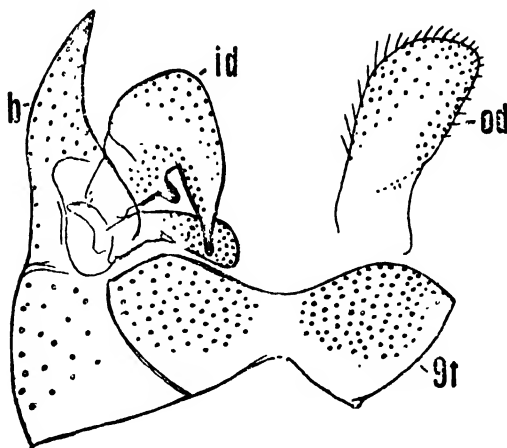
*Male*.—Length about 16 mm.; wing 17.5 mm.; antenna about 4.4 mm.

Frontal prolongation of head yellow, narrowly darkened on sides; nasus similarly yellow, distinct; palpi with basal segments yellowish brown, the relatively short terminal segment clearer brown. Antennae relatively short; scape and pedicel clear yellow; first flagellar segment brown, succeeding segments dark brown to brownish black basally, the remainder medium brown; flagellar segments moderately incised; verticils subequal to or a trifle exceeding the segments; terminal segment reduced to a tiny thimble. Head light cinnamon brown, the surface sparsely pruinose, with a distinct, median, dark brown vitta extending from the low vertical tubercle almost to the occiput.

Pronotum brownish yellow. Mesonotal praescutum with the ground colour grey, with four dark blackish grey stripes, the mesal edges of the intermediate pair very narrowly bordered by still darker, the remainder of stripes not or scarcely margined; humeral region and antero-lateral portions of praescutum yellow; interspaces of the ground colour, with numerous yellow setae; median region of scutum grey, more brownish at the suture, the lobes grey, each with two blackish grey areas; scutellum chiefly infuscated, the parascutella paler; mediotergite obscure brownish yellow, the posterior third more darkened. Pleura chiefly yellow, including the dorsopleural region, the anepisternum, ventral sternopleurite and ventral meron more infuscated. Halteres with stem yellow, knob dark brown, the apex again paler. Legs with the coxae obscure yellow, with long abundant setae; trochanters yellow; femora dark brown, the bases brightened, tip black, preceded by a conspicuous, obscure yellow ring that is about two-thirds as extensive as the blackened tip; tibiae dark brown; tarsi black. Wings with a weak brownish tinge, variegated by more cream-coloured areas, including a more or less distinct band beyond arculus, almost crossing the wing; a prestigmal area in cell  $R_1$ ; a poststigmal fascia extending from costa through cell 1st  $M_2$  into the base of cell  $M_3$ ; a conspicuous oval area at three-fourths the length of cell  $M$ ; wing-tip beyond the poststigmal band uniformly of the ground; stigma oval, darker brown; prearcular field clearer yellow; cells  $C$  and  $Sc$  yellow; veins brown. Venation:  $Rs$  long, about two and one-half times  $m-cu$ ; tip of  $R_{1+2}$  pale but entire, without trichia; petiole of cell  $M_1$  one-half longer than  $m$ .

First abdominal tergite and extreme base of second reddish, the succeeding tergites black; basal sternites reddish brown, passing into black on outer segments. Male hypopygium (text-fig. 5) with the tergite,

*9t*, entirely pale, the caudal margin broadly and evenly emarginate, apparently with no ventral lobes or blades and thus entirely unarmed



TEXT-FIG. 5.—*Tipula (Vestiplex) subreposita*, sp. nov.; male hypopygium, type.

except for abundant setae. Basistyle, *b*, produced caudad into an unusually strong and powerful spine, broad-based, the acute tip narrowly blackened. Outer dististyle, *od*, a simple flattened clavate blackened blade, its setae relatively short and sparse. Inner dististyle, *id*, of normal form, the rostral prolongation long, its tip obtuse, before apex with an acute spinous point (not shown in figure). Aedeagus short and stout, the penis slender.

*Habitat*.—India.

*Holotype*, ♂, Sureil, Mangpu, Darjiling District, Eastern Himalayas, altitude 5,000 feet, April-May 1917 (S. W. Kemp).

The nearest ally of the present fly is *Tipula (Vestiplex) reposita* Walker (*brevis* Brunetti) of which I have a wing available for comparison. In this latter species, *Rs* and *R*<sub>2+3</sub> are shorter and there are very definite pale areas in the outer ends of cells *1st A* and *2nd A*. Edwards (*Rec. Ind. Mus.* XXVI, p. 307, 1924) is responsible for the synonymy as given above. He further indicates that the species has the dististyle of very peculiar shape which is not the case in the present fly.

### ***Tipula (Vestiplex) himalayensis* Brunetti.**

1911. *Tipula himalayensis*, Brunetti, *Rec. Ind. Mus.* VI, p. 252.

*Lectotype*, ♂ Regd. No. 2407/20, Darjiling, Eastern Himalayas, altitude 6,000 feet, September 29, 1908 (E. Brunetti); in Indian Museum. This is the same as determined by Alexander, Brunetti and Edwards and evidently represents the true *himalayensis*.

Male hypopygium with the ninth tergite very small, largely concealed beneath the eighth tergite, the caudal margin deeply emarginate. Outer dististyle a flattened blackened lobe. Basistyle complete, the outer end produced caudad into a long point, the ventral margin with yellow setae. Eighth sternite unarmed.



**Tipula (Vestiplex) subtincta** Brunetti.

1912. *Tipula subtincta*, Brunetti, *Fauna Brit. India, Dipt. Nemat.*, p. 326, pl. vi, fig. 18 (genitalia).

Described from various stations in the Eastern and Western Himalayas and in the Khasi Hills, Assam. The following records of the species are available :

♂, Regd. No. 2477/20, Darjiling, Eastern Himalayas, altitude 7,000 feet, May 8, 1917 (E. Brunetti) ; Shamdang, Sikkim, altitude about 3,000 feet, September 7, 1909 (Indian Museum Collector), in poor condition ; Above Tura, Garo Hills, Assam, altitude 3,500-3,900 feet, September 1917 (Mrs. Kemp) ; Cherrapunjee, Assam, altitude 4,400 feet, October 2-8, 1914 (S. W. Kemp).

Are-description of the types is given below.

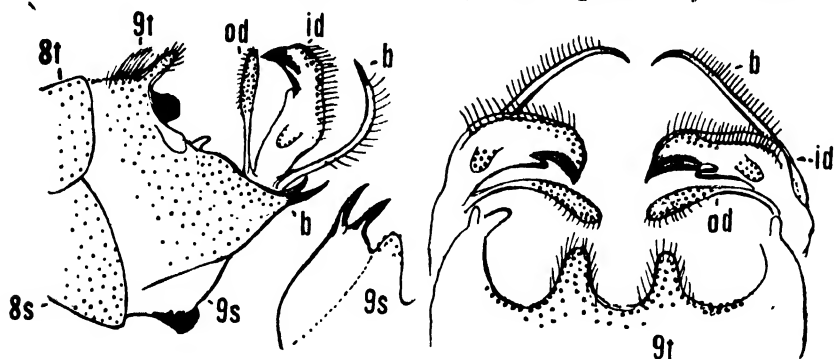
*Male*.—Length about 15–17 mm. ; wing 19–22 mm. ; antenna about 3.3–3.6 mm.

Frontal prolongation of head obscure yellow above, somewhat darker on sides ; nasus distinct ; palpi yellowish brown to obscure yellow. Antennae with basal three segments yellow ; succeeding segments dark brown, the distal ends of segments narrowly pale to produce a weak bicoloured appearance ; beyond the fourth or fifth flagellar segment, the organ becomes uniformly dark brown ; verticils very long and conspicuous. Head yellow, with a central vitta and the posterior borders of eyes darker brown.

Pronotum obscure yellow, variegated with darker. Mesonotal praescutum with ground colour light brown or yellowish brown, with four dark brown stripes that are narrowly bordered by darker brown, especially the intermediate stripes and the mesal edges of the lateral pair ; scutum obscure brownish yellow, each lobe with two dark brown areas ; posterior sclerites of mesonotum yellow, the scutellum and mediotergite with a narrow, dark brown, central vitta. Pleura yellow, the anepisternum, sternopleurite and ventral meron variegated with more brown areas ; ventral pleurotergite with a paler yellow pollinosity. Halteres yellow, the base of knob dark brown. Legs with the coxae pale, sparsely pruinose ; trochanters obscure yellow ; femora brownish black, restrictedly brightened at bases ; tibiae and tarsi dark brown to brownish black : legs very long and slender, especially the tarsi (middle leg, femur, 14 mm. ; tibia, 16 mm. ; tarsus, 37 mm.). Wings relatively narrow, with a conspicuous basal petiole ; ground colour pale brown, very sparsely variegated by darker brown and whitish subhyaline areas, the darker markings including a restricted post-arcular darkening ; small areas at origin of *Rs*, along cord, a wash along mid-length of outer radial cells, and a seam along vein *Cu* ; wing tip and outer medial field somewhat paler brown ; outer half of cell *M* weakly darkened, enclosing a restricted pale area about three-fourths the length of cell ; cell *C* uniformly brownish yellow, cell *Sc* darker brown ; veins brown, paler in the obliterative portions. Venation : *Rs* long, nearly two and one-half times *m-cu* ; *m-cu* shortly before fork of *M*<sub>3+4</sub>.

Abdomen relatively short and stout ; tergites brown medially, more reddish on either side, sublaterally with a narrow brownish black streak, the actual lateral border yellow : fifth and succeeding segments

more uniformly dark brown to black, only the lateral borders pale; sternites reddish brown, the outer segments darker, with very narrow yellow posterior margins; hypopygium black. Male hypopygium (text-fig. 6) with the tergite, *9t*, not separated from the sternite; basistyle, *b*, completely separated by a suture. Ninth tergite narrow, the caudal border with two finger-like fleshy lobes separated by a broad U-



TEXT-FIG. 6.—*Tipula (Vestiplex) subtineta* Brunetti; male hypopygium, details.

shaped notch, provided with short abundant setulae; dorsal surface of tergite with long erect setae; submedially on ventral face the tergite is produced caudad into two compressed blackened plates that lie parallel to one another, their margins microscopically roughened. Basistyle, *b*, at apex produced into two subequal short black spines lying side by side; in the Sikkim specimen, the outermost of these spines is longer and more slender, nearly twice the inner spine. At base of inner dististyle and the spines of the basistyle a conspicuous elongate pale rod that is gently curved, the acute tip narrowly blackened, the outer margin with a series of very long pale setae. Ventral median region of ninth sternite produced into an obtuse darkened lobe, directed ventral and slightly caudal. Outer dististyle, *od*, long and slender, narrowly spatulate on outer half, provided with long erect setae. Inner dististyle conspicuous, its face with an erect setiferous lobe. Penis very stout and conspicuous. Eighth sternite, *8s*, with margin straight and simple, not modified by lobes or hair pencils.

The only described species with which *subtineta* requires comparison is *Tipula (Vestiplex) quasimarmoratipennis* Brunetti, the type of which came from Darjiling; the species evidently being on the wing in spring (May). As indicated elsewhere in this paper, I am not entirely certain that the second female of *quasimarmoratipennis*, a paratype from Kurseong collected in September, is identical with the actual type. Edwards (*Rec. Ind. Mus.* XXVI, p. 305, 1924) who saw the type of this fly in Brunetti's collection believed that it was identical with the Formosan *T. (V.) biserra* Edwards. If this is indeed the case, I do not believe that *subtineta* is very close to *quasimarmoratipennis* since it differs conspicuously in the pattern of the antennae, legs and body. Both Edwards and Brunetti describe their species as having three praescutal stripes instead of the four in the present fly but the paratype of *quasimarmoratipennis* above mentioned has four such stripes. Brunetti

(*Rec. Ind. Mus.* XV, p. 262, 1918) records six further specimens of *quasimarmoratipennis* from the Garo Hills, Assam, with exactly the same data as one of the present *sublincta* records. Whether both *sublincta* and *quasimarmoratipennis* are included in such material remains in question. It should be noted that the presence of two spines on each basistyle of the male hypopygium of *sublincta* provides an almost unique character for the separation of the species from the other numerous regional forms of *Vestiplex* having the basistyle unarmed or with a single such spine.

***Tipula (Vestiplex) distifurca*, sp. nov.**

General colouration yellow or greyish yellow, the praescutum with four very conspicuous brown stripes that are narrowly bordered by darker ; head, scutellum and mediotergite with a capillary brown central vitta ; femora dark brown with a narrow yellow subterminal ring ; wings with a long basal petiole, pale brown, variegated with cream-coloured areas, including a post-stigmal band ; abdomen reddish yellow basally, the tergites with three narrow brown stripes, much broader and more conspicuous in female ; outer segments, including genitalia of both sexes, black ; male hypopygium with the spine of basistyle very small, the outer mesal angle further produced into a stouter arm ; basistyle bearing a long pale arm that splits at apex into two acute spines ; ovipositor with serrate cerci.

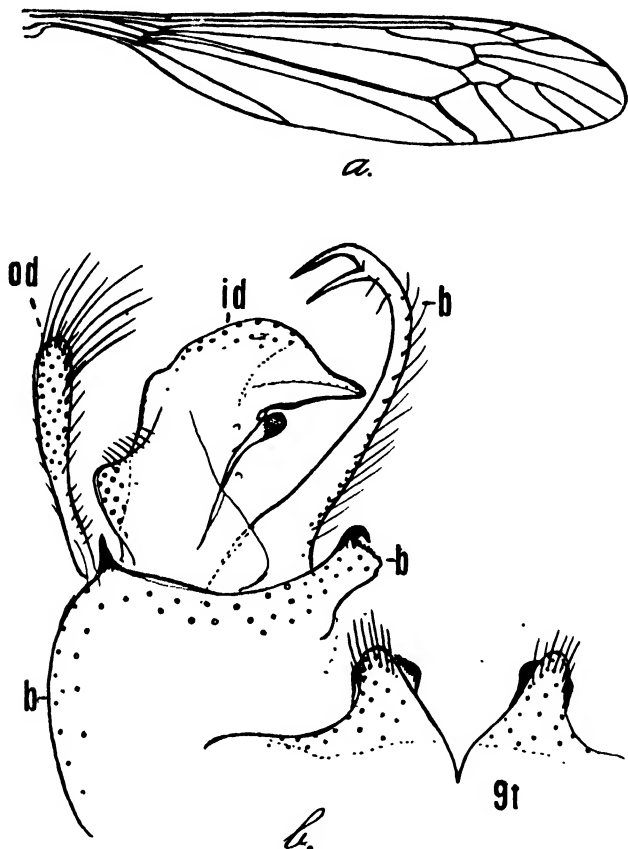
*Male*.—Length about 13-14 mm. ; wing 17-18 mm. ; antenna about 5 mm.

*Female*.—Length about 19 mm. ; wing 17 mm.

Frontal prolongation of head yellow pollinose over a darkened ground ; nasus elongate ; palpi with basal segments obscure brownish yellow, terminal segment black. Antennae of moderate length ; scape and pedicel yellow ; first flagellar segment brownish yellow, succeeding segments black, the incisures but especially the apices of the segments vaguely pale ; outer segments uniformly blackened ; flagellar segments moderately incised ; longest verticils nearly equal in length to the segments. Head obscure greyish yellow with a narrow dark brown median line.

Pronotum brown, yellow pollinose. Mesonotal praescutum greyish yellow, with four narrow brown stripes that are very distinct against the ground, the stripes more or less bordered by darker brown, the mesal edges of the intermediate pair involving the cephalic portion of the median interspace ; cephalic ends of intermediate dark stripes a little paler ; scutum greyish yellow, each lobe with two conspicuous dark brown areas, the more posterior one longer ; outer posterior portion of each scutal lobe restrictedly darkened ; posterior sclerites of notum obscure yellow, with a continuous median brown vitta that is somewhat narrower on the scutellum. Pleura almost uniform yellow, without distinct markings. Halteres with stem yellow, knob dark brown. Legs with coxae and trochanters yellow ; femora narrowly yellow at bases, the remainder dark brown with a narrow yellow subterminal ring before the broader black apex ; tibiae and tarsi brownish black to black. Wings (text-fig. 7a) with a long basal petiole ; ground colour

pale brown, variegated with cream-coloured areas, including a post-stigmal band from *C* to cell  $R_5$ ; numerous smaller pale areas in cells



TEXT-FIG. 7.—*Tipula (Vestiplus) distifurca*, sp. nov; a., venation; b., male hypopygium.

before cord, the largest in  $R_1$ , near outer end of cell *M*, a common area near bases of cells *R* and *M*, and across the bases of cells *Cu* to 2nd *A*, inclusive; cell *Sc* uniformly dark brown; obliterative areas across cell 1st  $M_2$  from the extreme outer end of cell *R* into the base of cell  $M_3$ ; veins brown, not markedly different in colour in the pale areas Venation:  $R_{1+2}$  distinct; *m-cu* a short distance before fork of  $M_{3+4}$ .

Abdomen with basal four segments reddish yellow, the fifth and succeeding segments black; in male with a median dark stripe on tergites, widest on first segment and base of second, thence narrowed and indistinct to almost obliterated; lateral borders of tergites restrictedly grey; fifth tergite more reddish brown basally and sublaterally; sternites with a more or less distinct median brown vitta. In female the basal seven tergites yellow with a broad, continuous, median, black vitta, with indications of a much narrower and less distinct sublateral stripe; lateral tergal borders narrowly grey; genital shield brownish black; ovipositor with cerci long and slender, brownish black, the lateral teeth small but numerous. Male hypopygium (text-fig. 7b) with

the dorsal lobes of tergite, *9t*, pale, gently divergent, narrowly obtuse and tufted with long setae at tips; immediately ventrad of these lobes are slightly broader, more blackened lobes, their apices obliquely truncate. Basistyle, *b*, with apex terminating in a small black spine, the mesal-caudal portion of style further produced into a strong arm that is directed mesad, its outer angle further produced into a curved black spine; from near the bases of the dististyles arises a long conspicuous arm that is split at apex into two powerful spines. Dististyles as figured, the outer, *od*, elongate-clavate, pale; inner style, *id*, with the rostral portion blackened, relatively narrow.

*Habitat*.—India (Punjab).

*Holotype*, ♂, round about Hurst Cottage, Bakrota Hill, Dalhousie, altitude 7,000 feet, May-June, 1927 (S. L. Hora). *Allotopotype*, ♀. *Paratopotypes*, 4 ♂♂, with the types.

The nearest relative of the present fly seems unquestionably to be *Tipula (Vestiplex) subtineta* Brunetti, which differs conspicuously in the hypopygial structures, as the simple pale arm and entirely different apical spines of the basistyle. The pale subterminal femoral ring is more like the otherwise quite distinct *T. (V.) himalayensis* Brunetti and differs from other relatives that are actually closer, as *subtineta* and *T. (V.) quasimarmoratipennis* Brunetti.

### ***Tipula (Vestiplex) quasimarmoratipennis* Brunetti.**

1912. *Tipula quasimarmoratipennis*, Brunetti, *Fauna Brit. India, Dipt. Nemat.*, pp. 320, 321, pl. v, fig. 14 (wing).

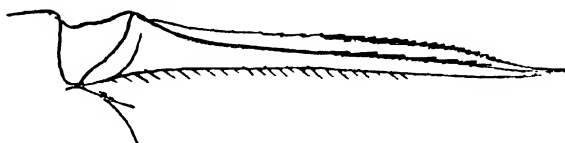
The type, ♀, Regd. No. 2427/20, was from Darjiling, May 23, 1910, collected by Brunetti, and has not been seen by the present writer. A paratype, ♀, Regd. No. 2428/20, collected at Kurseong in the Eastern Himalayas, altitude 5,000 feet, September 9, 1909, by N. Annandale, has been reexamined, but as indicated under the discussion of *subtineta*, is doubtfully conspecific with the type. This paratype may be re-described as follows:

*Female*.—Length about 23 mm.; wing 20 mm.

Frontal prolongation of head ochreous above, darker laterally, the stout nasus brownish ochreous; palpi dark brown. Antennae short; scape and pedicel obscure yellow; first flagellar segment fulvous yellow; succeeding flagellar segments weakly bicoloured, the basal enlargement of the segments brownish black, the apical portions paler brown; outer segments more uniformly darkened. Head buffy, with a broad, conspicuous, dark brown, median line extending from the anterior end of the vertical tubercle to the occiput.

Mesonotal praescutum obscure yellow, with four brown stripes, the intermediate pair narrowly margined internally with dark brown; lateral stripes greyish brown, the mesal margin broadly darker brown; scutum obscure brownish yellow, each lobe with two separated, darker brown areas; scutellum and postnotum brown, the former brighter at base; an interrupted brown median line. Pleura discoloured, the katepurotergite silken olive grey. Halteres pale brown, the base of stem brighter, knob darker brown with paler tips. Legs with the coxae brownish ochreous; trochanters pale brown; femora brownish yellow,

the tips narrowly but distinctly dark brown; tibiae light brown, the tips dark brown; tarsi passing into dark brown. Wings with pattern as figured by Brunetti (*loc. cit.*) but the venation slightly different: Distal section of  $R_2$  straight;  $R_3$  elongate, at tip deflected caudad so cell  $R_2$  at margin is extensive, about one-third wider than cell  $R_3$ . Veins, excepting  $C$ ,  $Sc$  and  $R$ , apparently destitute of macrotrichia.



TEXT-FIG. 8.—*Tipula (Vestiplex) quasimarmoratipennis* Brunetti; ovipositor.

Abdomen of moderate length only; tergites obscure yellow, with conspicuous dark brown median and sublateral stripes, the extreme margins of the tergites narrowly pale; sternites obscure yellow, a little darker medially. Ovipositor (text-fig. 8) with the elongate cerci slender, their outer margins serrate on distal two-thirds; hypovalvae rudimentary.

### ***Tipula (Tipulodina) simillima* Brunetti.**

1918. *Tipula simillima*, Brunetti, *Rec. Ind. Mus.* XV, p. 265.

The type, ♂, Regd. No. 6841/H1, was from Castle Rock, North Kanara District, on the Goa Frontier, western coast of Bombay Presidency, collected October 11-26, 1916, by S. W. Kemp. A re-description of the type is given below.

*Male*.---Length about 17 mm.; wing about 17 mm. (Brunetti gives the length as 12-13 mm. but this is far too little).

Antennae very short, if bent backward ending far before the wing-root; scape pale yellow at base, the apex darkened; pedicel obscure yellow; flagellum brownish black. Anterior vertex produced into a very slender, acute, median tubercle.

Fore and middle legs with the pale subapical ring of femur about twice as wide as the dark apex; on posterior femora the yellow ring greatly reduced, scarcely one-half as extensive as the blackened apex; fore and middle tibiae with only the subapical white rings, these broad, nearly apical in position, only the extreme tip of the segment blackened; posterior tibiae with this ring a trifle wider, together with a subbasal white ring shortly beyond proximal end of segment; basitarsi black, the tips broadly whitened, narrowest on fore legs where it includes less than the distal third, widest on posterior legs where about the distal two-fifths is included; second tarsal segment broadly blackened at base, most extensive on the fore legs where about the basal half is included, narrowest on the posterior legs where only the extreme base is blackened; fore legs with tarsal segment three dark basally, paler distally; remainder of tarsi white, the terminal two segments blackened. Wings hyaline, iridescent; brown pattern restricted; wing apex including outer ends of cells  $R_2$ ,  $R_3$  and  $R_3$ , together with the extreme cephalic margin of  $M_1$ ; stigma small, confluent with a small cloud on anterior

cord; *m-cu* and distal section of *Cu*<sub>1</sub> narrowly bordered with brown; no dark marking in cell *M*.

Male hypopygium with the ninth tergite dark grey, transverse, the caudal margin broadly emarginate, fringed with dark setae. Hypopygium entirely blackened; suture between tergite and sternite incomplete; eighth tergite telescoped beneath the seventh; seventh and eighth sternites with conspicuous yellow setae. Inner dististyle profoundly bifid, both arms blackened, more or less setiferous.

Three males were sent to me for study by the Indian Museum in 1928, presumably the three specimens mentioned in the original diagnosis. However, I have a still additional male, received by exchange with Edwards, bearing exactly the same data and agreeing entirely with the type.

### ***Tipula (Oreomyza) striatipennis* Brunetti.**

1912. *Tipula striatipennis*, Brunetti, *Fauna Brit. India, Dipt. Nemat.*, pp. 325, 326, pl. v, fig. 16 (wing).

The type, ♀, Regd. No. 2432/20, was from Kurseong, Eastern Himalayas, altitude 5,000 feet, collected July 6, 1908, by N. Annandale. Edwards (*Rec. Ind. Mus.* XXVI, p. 305, 1924) believed that the species was identical with *Tipula (Oreomyza) quadrifasciata* Matsumura [*Thousand Insects Japan, Addit.* II, p. 460, pl. xxv, fig. 3 (wing and body), 1916] but in my opinion the two species are entirely distinct, as will be shown by the following comparison.

A re-description of type is given below.

*Females*.—Length about 11-11.5 mm.; wing 10.6 mm.

Frontal prolongation of head, including the nasus, brownish black; palpi black. Antennae with scape and pedicel light brown; first flagellar segment black, its tip reddish brown; succeeding flagellar segments bright reddish brown, only the terminal segments becoming darker brown. Head dark grey, with a capillary brown median vitta and numerous dark setigerous punctures.

Mesonotal praescutum yellowish grey, with three brown stripes, the median one broad in front and here indistinctly divided by a dull grey area; scutum and scutellum grey, with a continuous, capillary, brown, median vitta; scutal lobes each with two confluent brown spots; postnotum brownish grey. Pleura dark grey, with a relatively indistinct longitudinal paler stripe. Halteres obscure yellow, the knobs brown. Legs brownish black, the femoral bases only very narrowly and vaguely brightened. Wings whitish subhyaline, quadrivittate with brown, almost as figured by Brunetti (*loc. cit.*). Distal section of *R*<sub>1+2</sub> atrophied, leaving only a minute spur.

Abdominal tergites brownish yellow, the outer segments darker brown, the caudal and sublateral margins of the segments dark, the extreme caudo-lateral portions of the tergites restrictedly pale; outer sternites chiefly darkened. Ovipositor with the elongate cerci slender, chestnut to horn coloured; margins smooth.

***Tipula (Oreomyza) quadrifasciata* Matsumura.**

1918. *Tipula aluco*, Alexander, *Journ. N. Y. Ent. Soc.* XXVI, pp. 70, 71.

The types of *aluco* are preserved in alcohol which has changed the colour of the pruinosity. The following description was made from freshly preserved dry females. It may be noted that the measurements given by Matsumura for his species are too great. I have paratypes of *quadrifasciata* from Kyoto, Japan, kindly presented to me by Dr. Akio Nohira who discovered the species.

Frontal prolongation of head longer, clear light grey above, the nasus conspicuous, light yellow; palpi dark brown. Antennae with the scape, pedicel and first flagellar segment yellow, the remaining flagellar segments dark brown. In the male the flagellum weakly bicoloured, the basal enlargements of the segments a little darker than the apical portions.

Praescutal interspaces with the brown setigerous punctures much larger and more conspicuous than in *striatipennis*; median brown line on scutum and scutellum obsolete or nearly so. Pleura clear light grey. Wings with the brown bands narrower, that at origin of *Rs* only about one-half as wide as the preceding white band. Venation: Cell 1st  $M_2$  small, pentagonal, the longest face being the second section of  $M_{1+2}$ , the next being the basal section of  $M_3$  which is longer than  $M_{3+4}$ ,  $m$  shortest. In *striatipennis*  $M_{3+4}$  longer than  $M_3$ , as figured by Brunetti.

Abdominal tergites obscure yellow with a conspicuous dorso-median dark brown stripe that is broader behind; caudal margins of the sub-terminal segments narrowly pale. Ovipositor with the genital shield shiny chestnut brown, the elongate cerci blackened.

***Tripula (Lunatipula) marmoratipennis* Brunetti.**

1912. *Tipula marmoratipennis*, Brunetti, *Fauna Brit. India, Dipt. Nemat.*, pp. 319-320, pl. v, fig. 13 (wing).

The holotype, ♀, Regd. No. 2425/20, was from Darjiling, Eastern Himalayas, altitude 7,000 feet, May 24, 1910 (not April, as stated by Brunetti), collected by E. Brunetti. A paratype, ♀, Regd. No. 2426/20, likewise from Darjiling, taken August 7, 1909, by C. Paiva. Both types were studied. The re-description follows.

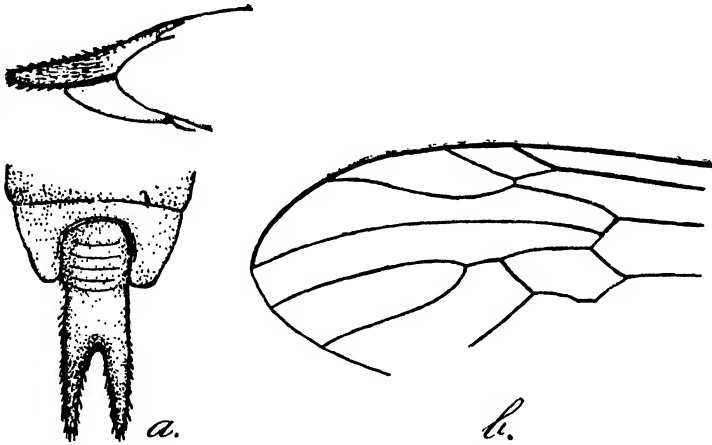
*Female*.—Length about 16 mm.; wing 22 mm.

Frontal prolongation of head obscure yellow above, with a vague median brown line, the sides darker; nasus short and stout; palpi brown, the outer segments passing into orange. Antennae short, obscure yellow; flagellar segments obscure fulvous, their bases scarcely darkened. Head light ochreous, the vertical tubercle whitened; vertex with a narrow dark brown median vitta, widened in front.

Mesonotal praescutum yellowish grey with four olive brown stripes that are narrowly margined with darker brown, the lateral stripes more conspicuously darkened along the mesal margin; interspaces with numerous pale erect setae, the punctures inconspicuous; pseudosutural foveae small, circular; scutum grey, each lobe with two confluent olive brown areas, the triangular posterior one larger; scutellum and mediotergite yellowish grey with a continuous median brown vitta; para-



scutella dark, smooth. Pleura pruinose with grey and pale olive. Halteres obscure yellow, the knobs dark brown with orange apices. Legs with the coxae pale olive grey; trochanters reddish brown; femora obscure yellow, the tips narrowly brownish black; tibiae and tarsi brownish black. Wings pale yellowish, cells *C* and *Sc* darker yellow; stigma yellowish brown; wing surface variegated with grey and pale brown; pattern entirely as figured by Brunetti (*loc. cit.*). Venation of Brunetti's figure slightly inaccurate, especially in the shape



TEXT-FIG. 9.—*Tipula* (*Lunatipula*) *marmoratipennis* Brunetti, type; a., ovipositor; b., venation.

of cell  $R_2$  and the course of vein  $R_3$  which is strongly arched, constricting cell  $R_3$  so that it is narrowest before midlength (text-fig. 9b) petiole of cell  $M_1$  shorter than  $m$ .

Abdomen with tergites one to five inclusive dark orange fulvous, trivittate with black, the median stripe interrupted; sublateral stripes more continuous; segments with silvery grey lateral areas; remainder of tergites darker brown, pruinose, more heavily so on segments seven to nine; sternites pale, the basal segments pruinose, the segments with a darker brown lateral stripe. Ovipositor (text-fig. 9a) with the valves small and fleshy, the cerci lying side by side, parallel, their margins setiferous; hypovalvae smaller, compressed.

Related to *Tipula* (*Lunatipula*) *holoteles* Alexander, *T. (L.) naviculifer* Alexander, and *T. (L.) shogun* Alexander, all of Japan.

### ***Nephrotoma perhorrida*, sp. nov.**

General colouration yellow, the praescutum with three blackish grey or plumbeous stripes that are narrowly bordered by velvety black, the central stripe entire or nearly so; antennae black, only the pedicel more brownish; head with a conspicuous T-shaped brown area, the stem reaching the occipital brand; pleura heavily patterned with brownish black; wings with cells before cord strongly infuscated, those beyond cord clearer; abdominal tergites obscure yellow with three broad dark brown stripes, the outer segments uniformly blackened; male hypopygium very conspicuous; basistyle produced caudad into a cylindrica

lobe, the ventral margin with unusually long, coarse setae; eighth sternite produced medially into a long tongue-like lobe.

*Male*.—Length about 10-11 mm.; wing 9-11 mm.; antenna 3.3-3.4 mm.

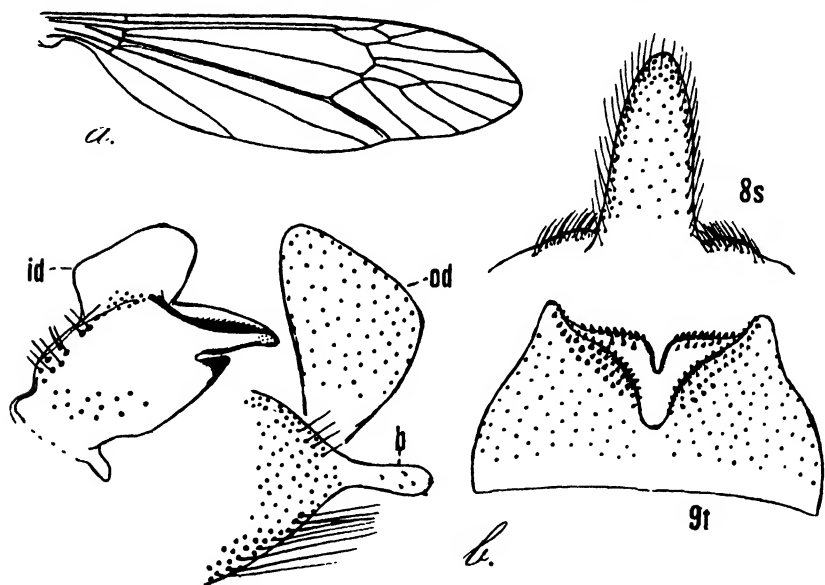
*Female*.—Length about 13-14 mm.; wing 11-12 mm.

Frontal prolongation of head above black, including the nasus, on sides and beneath yellow; palpi black. Antennae black, the pedicel more brownish; flagellar segments only moderately incised, the basal enlargements relatively small; longest verticils subequal in length to the segments, unilaterally arranged, those on opposite face of segment reduced to short spinous bristles. Vertical tubercle yellow, with a conspicuous median impressed line; posterior vertex with a T-shaped dark mark extending from either eye behind the vertical tubercle, the stem extending as a median area to the occiput; occipital brand small and ill-delimited in the general darkened area; head behind with conspicuous black and longer yellow setae.

Pronotum yellow, the sides conspicuously dark brown. Mesonotal praescutum with the ground light yellow, with three blackish grey or plumbeous stripes that are narrowly bordered by velvety black, the intermediate pair barely indicated by these mesal edges so the central stripe is entire or virtually so; a conspicuous dark brown cloud opposite anterior ends of lateral stripes, not quite reaching the lateral border, the stripes themselves not outcurved; scutum with median area and extreme lateral portions of lobes yellow, each lobe chiefly covered by a blackish grey area that is narrowly bordered by velvety black, the suture chiefly dark; scutellum brownish black, parascutella obscure yellow; mediotergite with a broad dark brown central stripe, wider and darker on posterior border; posterior lateral portions of mediotergite with relatively few but conspicuous coarse black setae; pleurotergite with katepleurotergite obscure yellow, just above the halteres bordered by dark brown, the anapleurotergite more infuscated. Pleura yellow, very conspicuously patterned with dark brown or brownish black on the anepisternum, ventral sternopleurite, ventral meron, and along the suture between anepisternum and pteropleurite. Halteres with stem obscure brownish yellow, knob dark brown, the apex vaguely pale yellow. Legs with coxae obscure yellow, more or less infuscated basally, especially in front; trochanters yellow; femora pale brown to yellowish brown, the tips weakly darkened; remainder of legs obscure yellow, the terminal tarsal segments passing into black. Wings (text-fig. 10a) with cells before cord rather strongly infuscated, beyond the cord much paler; stigma oval, dark brown; a distinct, paler brown cloud on anterior cord; veins brown. Stigma with numerous trichia before  $R_2$ ; wing dilated in the Anal field. Venation:  $R_s$  a little shorter than  $m-cu$ ; cell  $M_1$  narrowly to broadly sessile.

Abdominal tergites obscure yellow, with three broad, dark brown stripes, the median one narrowly interrupted at the posterior border of the intermediate segments; sixth and succeeding segments uniformly darkened, sternites yellow. Male hypopygium (text-fig. 10b) having the tergite,  $9t$ , with an upper plate that bears a broad U-shaped notch, the lobes densely set with microscopic blackened points, and a lower plate

divided into lobes by a shorter and much narrower median notch, the truncated margins of the lobes likewise set with points. Basistyle, *b*,



TEXT-FIG. 10.—*Nephrotoma perhorrida*, sp. nov.: *a.*, venation; *b.*, male hypopygium, details.

conically produced, the apex abruptly prolonged into a cylindrical lobe that bears a few chitinized triangular points; ventral surface of basistyle with very long, conspicuous yellow setae, the dorsal surface with less conspicuous bristles. Outer dististyle, *od*, unusually broad, the tip obtuse. Inner dististyle, *id*, with a high dorsal crest; beak slender. Eighth sternite, *8s*, produced medially into a very long and conspicuous liguliform lobe, the apex narrowly obtuse, the surface with abundant long black setae; subtending shoulders of the lobe likewise with long conspicuous setae.

*Habitat*.—India (Khasi Hills).

*Holotype*, ♂, Cherrapunji, altitude 4,000 feet, 1935 (Sircar).

*Allotopotype*, ♀. *Paratopotypes*, 15 ♂ ♀. Paratypes deposited in the Indian Museum.

*Nephrotoma perhorrida* is very different from all other described regional species. The remarkable male hypopygium, especially the long-produced basistyle and the elongate liguliform lobe of the eighth sternite, will readily separate the fly from other generally similar regional forms, as *Nephrotoma pleurinotata* (Brunetti).

#### Subfamily CYLINDROTOMINAE

#### **Stibadocerella pristina** Brunetti.

1918. *Stibadocerella latefurcata*, Brunetti (*lapsus calami*), *Rec. Ind. Mus.* XV, p. 280.

1918. *Stibadocerella pristina*, Brunetti, *Ibid.*, p. 283.

A paratype, ♂, Regd. No. 3967/H2 from above Tura, Garo Hills, Assam, altitude 3,500-3,900 feet, July 1917 (S. W. Kemp).

*Male*.—Length about 10 mm.; wing 9.2 mm.; antenna about 13 mm.

Antennae (male) much longer than the body, pale yellow, the outer segments of flagellum darker. Body colouration as described by Brunetti. Praescutal stripes distinctly separated. Pale ring at base of tibia distinct; pale apex of fore tibia relatively wide (1.7 mm.), slightly thickened, the setae similarly white; fore and middle basitarsi about as long as tibia, brown, only the extreme apex of each a little whitened. Wings hyaline, the veins black. Venation:  $Sc_1$  ending before  $r-m$ ,  $Sc_2$  at its tip; second section of  $Rs$  a little shorter than the basal section;  $R_{2+3}$  oblique; free tip of  $Sc_2$  and  $R_{1+2}$  entirely atrophied; cell  $1st\ M_2$  large, roughly rectangular;  $m-cu$  longer than the distal section of  $Cu_1$ ; vein  $Cu_2$  evident to opposite  $m-cu$ ; vein  $1st\ A$  long, nearly straight; vein  $2nd\ A$  very short, opposite the arculus becoming confluent with the Anal margin of wing, to all intents and purposes, lacking.

#### Subfamily LIMONIINAE.

#### Tribe LIMONIINI.

#### **Limonia (Limonia) albitarsis** (Alexander).

1915. *Dicranomyia albitarsis*, Alexander, *Proc. U. S. Nat. Mus.* XLIX, pp. 159, 160.

1916. *Dicranomyia tinctipennis*, de Meijere, *Tijd. v. Ent.* LVIII, Suppl., p. 66.

A broken specimen, Federated Malay States, Selangor-Pahang Boundary, Ginting Bidai, altitude 2,000 feet, April 1917 (C. Boden Kloss).

*Limonia (Doaneomyia) altilarsis* (Edwards) from New Hebrides [*Ann. Mag. Nat. Hist.* (9) XX, p. 233, 1927] was erroneously so printed though obviously intended for *albitarsis*. Since the specific name *albitarsis* would have been preoccupied in the genus by the present name, it seems advisable to retain the misprinted name *altilarsis*, even though without significance in the instance where used.

#### **Limonia (Libnotes) greeni** (Edwards).

1928. *Libnotes greeni* Edwards, *Journ. Fed. Malay States Mus.* XIV, pp. 76, 82.

Metatypes of both sexes from Suduganga, Ceylon, bred October 21, 1921 from diseased bark of *Hevea* (R. Senior-White). Ceylonese specimens had been determined by Senior-White and Brunetti (*Rec. Ind. Mus.* XV, pp. 294, 295, 1918) as *Limonia (Libnotes) poeciloptera* (Osten Sacken).

#### **Limonia (Discobola) sp. prox. annulata** (Linnaeus).

1758. *Tipula annulata*, Linnaeus, *Syst. Nat.*, Ed. 10; p. 586.

1824. *Limnobia, Argus*, Say, *Long's Exped. to St. Peter's River*, Append. 2, p. 358.

One badly injured specimen of indeterminate sex, Assam, Khasi Hills, forest west of dak bungalow, Mawphlong, April 13, 1927 (Gopi Ram). Despite its poor condition this specimen is of unusual interest

since the subgenus *Discobola* Osten Sacken had not before been recorded from British India. I feel relatively certain that the specimen pertains to *annulata*.

*L. (D.) annulata* has a vast range throughout the Holarctic Region, including northern North America and northern Eurasia as far south as the high mountains of the Philippines and Borneo (Kinabalu). From Kinabalu, two additional species of the subgenus have been described by Edwards. Two further species have been recorded from the Indo-Himalayan Region, including western China; *L. (D.) taiwanella* Alexander (Mount Omei, Szechwan, altitude 9,000 feet) and *L. (D.) armorica* Edwards, Mss., (Adung Valley, northeast Burma, altitude 12,000 feet). The latter fly is most similar to *taiwanella* yet amply distinct, being very large (wing, male, 12 mm.) and with a distinctive wing pattern, the nuclei of the annulata areas being unusually large and dark, almost obliterating the inner pale ring of the annulus, such being the condition of all costal ocellate markings; furthermore the supplementary brown dots are more numerous than in any other regional species, being especially numerous in cells  $R_1$ ,  $R$ ,  $M$ , 1st  $M_2$ ,  $Cu$ , 1st  $A$  and 2nd  $A$ . The male hypopygium agrees somewhat closely with that of *taiwanella*, especially in the very conspicuous lateral lobes of the tergite and the long slender rostral prolongation of the ventral dististyle. There are distinct differences in the dorsal dististyle which is longer and more gently curved than in *taiwanella*, and in the spines of the rostral prolongation which are more widely separated from one another. The more elongate ventro-mesal lobe of basistyle, the unexpanded tips of the gonapophyses, and the slightly capitate apex of the aedeagus show further minor but apparently constant differences for separating *armorica* from *taiwanella*. *L. (D.) annulata* shows no supplementary brown dots in any of the cells of wing and the structure of the male hypopygium is entirely distinct.

***Limonia (Dicranomyia) bhutanica*, sp. nov.**

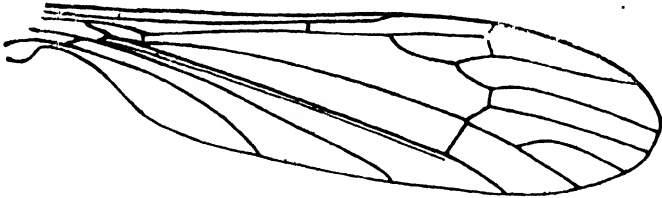
Size very small (wing, female, 3.5 mm.); general colouration brown, the praescutum with three more or less confluent, darker brown stripes; antennae brownish black; flagellar segments oval, all but the three or four outer ones with conspicuous apical pedicels; anterior vertex wide; legs obscure yellow; wings greyish subhyaline, stigma lacking;  $Sc_1$  ending opposite origin of  $Rs$ ;  $Sc_1$  very long, exceeding  $Rs$  in length; cell  $M_2$  open by the atrophy of  $m$ ; cell 2nd  $A$  wide.

*Female*.—Length about 3 mm.; wing 3.5 mm.

Rostrum dark brown; palpi pale brown. Antennae brownish black throughout; flagellar segments oval, with conspicuous glabrous apical pedicels, especially long, conspicuous and abrupt on the basal segments; distal three or four segments with pedicels short to lacking; terminal segment a very little longer than the penultimate; verticils long and conspicuous, exceeding the segments in length. Head light brown; anterior vertex wide, approximately four times the diameter of scape; ommatidia of eyes relatively coarse.

Pronotum and mesonotum uniformly medium brown, the praescutum with three more or less confluent darker brown stripes; posterior sclerites of notum destroyed by pinning. Pleura brown, with indica-

tions of more blackened areas on propleura above the fore coxae and beneath the wing root. Halteres obscure yellow. Legs with the coxae brown; trochanters obscure yellow; only a single detached leg remains, this obscure yellow, the terminal two tarsal segments darkened; claws simple. Wings (text-fig. 11) greyish subhyaline, the base slightly more



TEX-FIG. 11.—*Limonia (Dicranomyia) bhutanica*, sp. nov.; venation.

brightened; stigma lacking; veins very pale brown. Venation:  $Sc_1$  ending opposite origin of  $R_s$ ,  $Sc_2$  very far from its tip so vein  $Sc_1$  is longer than the arcuated  $R_s$ ; basal section of  $R_{4+5}$  arcuated, about two-thirds  $R_s$ ; cell  $M_2$  open by atrophy of  $m$ ; petiole of cell  $M_3$  about two-thirds the cell; cell  $2nd\ A$  unusually wide, vein  $2nd\ A$  arcuated.

Abdomen yellowish brown, somewhat darkened laterally; sternites paler; valves of ovipositor horn-yellow, the hypovalvae blackened basally; cerci very slender.

*Habitat*.—Assam-Bhutan Border.

*Holotype*, ♀, northeast Mangaldai District, December 30-31, 1910 (S. W. Kemp).

The most generally similar regional species of *Dicranomyia* having cell  $M_2$  of the wings open by the atrophy of  $m$  are *Limonia (Dicranomyia) innocua* (Alexander) and *L. (D.) absens* (Brunetti). Both of these species are much larger than the present fly and with the colouration of the body and wings distinct. Superficially the present fly is more like *L. (D.) aperta* (Wahlgren) of northern Europe and *L. (D.) brevivena* (Osten Sacken) of North America. The structure of the antennae indicates that the present fly is very distinct from all of the above mentioned species, more nearly approaching several species in the subgenus *Limonia* Meigen. The fly is one of the smallest members of the entire genus *Limonia* yet made known.

### ***Limonia (Geranomyia) cernua*, sp. nov.**

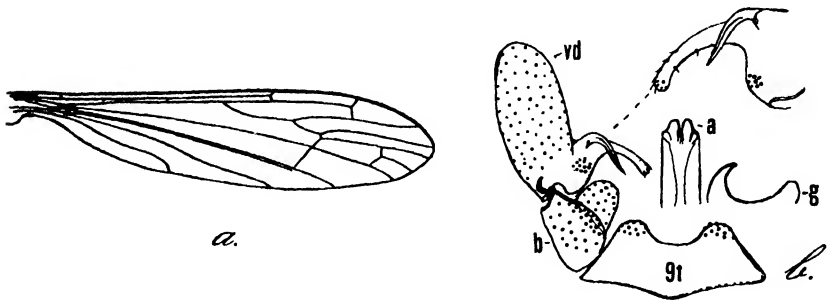
General colouration of mesonotum obscure yellow, the praescutum with three narrow dark brown stripes; scutellum yellow with a conspicuous brownish black median vitta; postnotum darkened; pleura obscure brownish yellow, the dorsal pleurites vaguely darker; knobs of halteres brownish black; femora obscure yellow with a vague darker subterminal ring; wings cream yellow, slightly darker around margin, with very conspicuous brown costal areas, those over origin of  $R_s$  and at stigma very large; no brown spots along vein  $Cu$ ;  $Sc$  relatively long; cell  $1st\ M_2$  elongate, exceeding any of the veins beyond it;  $m-cu$  close to fork of  $M$ ; male hypopygium with the dorsal dististyle lacking; ventral dististyle very large and fleshy, its rostral prolongation slender,

with two decurved spines from a common tubercle, these spines fused basally or very closely approximated on their outer portion.

*Male*.—Length, excluding rostrum, about 6.5-7 mm.; wing 7.5-8 mm.; rostrum about 2.3-2.5 mm.

Rostrum relatively short, black. Antennae black throughout; flagellar segments oval; verticils relatively inconspicuous. Anterior vertex light grey, the colour vaguely continued caudad onto the dark brownish grey posterior portion of head; anterior vertex reduced to a narrow strip, less than the diameter of scape.

Pronotum obscure yellow, darkened laterally. Mesonotal praescutum obscure yellow, with three narrow dark brown stripes, the median vitta narrower than the laterals, subequal in width to the interspaces; lateral stripes widened behind and here more greyish, crossing the suture and broadly suffusing the scutal lobes, the latter area narrowly bordered mesally by more brownish black; lateral borders of scutal lobes and the median area of scutum yellow, the latter with vague indications of a darkened median vitta; scutellum yellow, with a very conspicuous brownish black median dash that does not reach the posterior border, parascutella pale brown; postnotum chiefly dark brown, paler along the suture between anepisternum and sternopleurite. Pleura chiefly obscure brownish yellow or reddish yellow, with indications of a darker dorso-longitudinal stripe extending from the propleura backwards, the exact limits difficult to determine because of damage caused by pinning. Halteres with stem yellow, knob brownish black. Legs with the coxae and trochanters yellow; femora obscure yellow with very vague indications of a darker ring about equal in extent to the yellow apex; tibiae and tarsi yellow, the terminal tarsal segments darkened. Wings (text-fig. 12a) with a weak brown tinge, the central portion of disk more cream



TEXT-FIG. 12.—*Limonia (Geranomyia) cernua*, sp. nov.; a., venation; b., male hypopygium.

coloured; a heavy brown pattern, chiefly costal in distribution, arranged as follows: At *h*, continued caudad over the arcular region; at supernumerary crossvein in cell *Sc*, extending from *C* to *M*, narrower in cell *R*; a very extensive costal area from above origin of *Rs* to beyond fork of *Sc*, continuously darkened in cells *C* and *Sc* or very narrowly interrupted; in cell *R* following along *Rs* for about one-half the length of the vein, not reaching vein *M* behind; a further posterior extension in cell *R*<sub>1</sub> opposite fork of *Sc*, not quite reaching *Rs* behind; a further major darkening in region of the stigma, in extent subequal to the last

area, with a narrow posterior extension across cell  $R_3$  before midlength ; beyond the stigma are further narrower areas at tip of  $R_{2+3}$ , continued caudad to vein  $R_{4+5}$ , and more diffusely at wing-tip ; cord and outer end of cell 1st  $M_2$  more narrowly seamed with brown ; narrow brown marginal clouds at ends of longitudinal veins, especially *Cu*, 1st *A* and 2nd *A* ; veins obscure yellow, very slightly darker in the patterned areas. Costal fringe (male) short and inconspicuous. Venation : *Sc* relatively long,  $Sc_1$  ending about opposite three-fifths *Rs*,  $Sc_2$  at its tip ; a supernumerary crossvein in cell *Sc* ; *Rs* weakly angulated at origin ; cell 1st  $M_2$  elongate, longer than any of the veins beyond it, more than twice as long as the distal section of  $M_4$  ; *m-cu* close to fork of *M* ; vein 2nd *A* sinuous.

Abdominal tergites dark brown, the posterior borders of the segments broadly more greyish ; sternites reddish yellow ; hypopygium dark. Male hypopygium (text-fig. 12*b*) with the caudal margin of ninth tergite, 9*t*, broadly emarginate, the lateral lobes obtuse, slightly darkened, provided with numerous coarse setae. Basistyle, *b*, small, the ventromesal lobe short and stout, simple. Dorsal dististyle apparently lacking. Ventral dististyle, *vd*, large and fleshy, elongate, its total area about four or five times the basistyle ; rostral prolongation long and slender, at its base on upper face with a common tubercle bearing two strong confluent or very closely approximated spines that are bent cephalad across the face of the prolongation, one of the spines longer and a trifle stouter than the other, both acute at tips ; apex of prolongation a little dilated, provided with microscopic setae. Mesal-apical lobe of gonapophysis, *g*, appearing as a smooth, darkened, slightly curved horn.

*Habitat*.—British India (Punjab, Assam).

*Holotype*, ♂, Punjab, Dalhousie, stream next to Punj-pul Nallah, altitude 6,500 feet, May 8, 1927 (S. L. Hora). *Paratypes*, alcoholic ♂ ♀, in poor condition, Assam, Khasi Hills, Dumpep, October 2-18, 1929 (S. L. Hora).

By means of Brunetti's key to the species of British India (*Fauna*, etc., p. 388), the present fly runs to *Limonia* (*Geranomyia*) *semistriata* (Brunetti), which with the subsequently described *L. (G.) flaviventris* (Brunetti) and *L. (G.) poliophara* Alexander, and the fly described here-with as *L. (G.) fortibasis*, sp. nov., are the most similar species. The fly is readily told from all of the above with the exception of *fortibasis* by the structure of the male hypopygium, especially the loss of the dorsal dististyle. The three Oriental species possessing this character are *L. (G.) feuerborni* Alexander, of the Malayan Islands ; *L. (G.) fortibasis*, sp. nov. ; and the present fly ; all differ among themselves in the nature of the wing pattern and the details of structure of the male hypopygium.

### ***Limonia* (*Geranomyia*) *fortibasis*, sp. nov.**

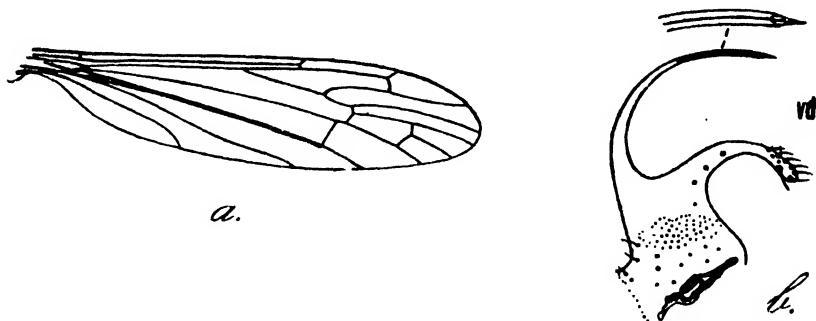
*Male*.—Length, excluding rostrum, about 6-7 mm. ; wing 6.5-8 mm. ; rostrum about 2.5-3 mm.

*Female*.—Length, excluding rostrum, about 6 mm. ; wing 7 mm. ; rostrum about 2.5-3 mm.



Very similar to *L. (G.) cernua*, sp. nov., differing especially in the details of structure of the male hypopygium.

Rostrum black throughout. Praescutal stripes narrow but relatively ill-defined; scutal lobes extensively darkened; median area of scutum and the scutellum obscure yellow, with a narrow dark brown median vitta; postnotum uniformly darkened. Pleura obscure yellow, the dorsal portions slightly more darkened. Femora light brown, the tips narrowly and vaguely yellow, without a distinct brown subterminal ring; tibiae and tarsi brown, the terminal tarsal segments darker. Wings (text-fig. 13a) with the dark pattern much as in *cernua*, the areas



TEXT-FIG. 13.—*Limonia (Geranomyia) fortibasis*, sp. nov.; a., venation; b., male hypopygium, details.

over origin of *Rs* and fork of *Sc* entirely separate. Venation: Cell 1st  $M_2$  a little shorter; *m-cu* a short distance before fork of *M*, in cases this distance between one-third to one-fourth the length of *m-cu*.

Abdominal tergites dark brown, the sternites obscure yellow; hypopygium brownish yellow. Male hypopygium (text-fig. 13b) much as in *cernua* but differing conspicuously in the rostral prolongation of the ventral dististyle, *vd*. This latter is unusually wide across the base, the point of attachment with the main body of the style evidently very weak since this latter is broken and lost in almost all specimens examined; spines of the prolongation arising from a powerful base, the spines entirely fused and without trace of suture on basal half; on distal half the dividing suture is evident but to all intents and purposes there remains a single spine clear to the acute tip; spine from one-third to one-half longer than the length of the prolongation beyond it and not lying across the face of the prolongation, as in *cernua*; prolongation beyond the spine long and slender, gently curved, provided with several long setae at apex. Dorsal dististyle lacking, as in *feuerborni* Alexander and *cernua*, sp. nov.

*Habitat*.—Assam (Khasi Hills).

*Holotype*, alcoholic ♂, Dumpep, October 2-18, 1929 (S. L. Hora).

*Allotopotype*, ♀. *Paratopotype*, 1 broken ♂.

### ***Limonia (Geranomyia) graveleyana*, sp. nov.**

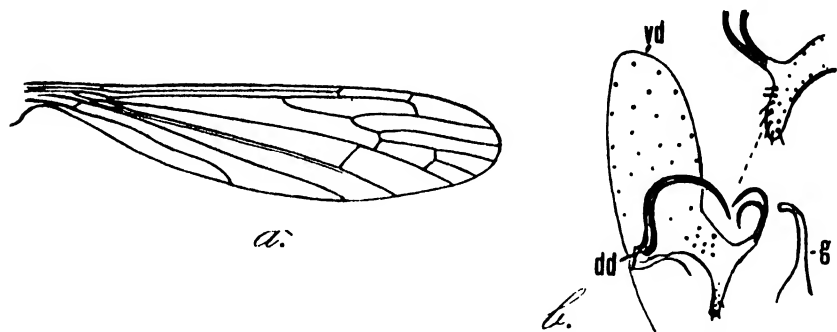
General colouration grey, the praescutum with a broad blackish median stripe; knob of halteres darkened; femora pale brown, tibiae and tarsi darker brown; wings weakly tinged with brown, unpatterned

except for the short-oval pale brown stigma; costal fringe relatively long and dense; *Sc* long; male hypopygium with the dorsal dististyle long and strongly curved; ventral dististyle very large and fleshy; rostral prolongation bearing two strongly curved spines from a stout common tubercle; mesal-apical lobe of gonapophysis long and slender, entirely pale.

*Male*.—Length, excluding rostrum, about 4.8-5.2 mm.; wing 5-5.7 mm.; rostrum about 1.9-2 mm.

Rostrum relatively long, dark brown throughout. Antennae short, black; flagellar segments oval, relatively crowded. Head dark grey, the anterior vertex and a line of equal width back from it to the occiput clear light grey.

Pronotum blackish, grey laterally. Mesonotal praescutum grey, with the disk chiefly occupied by a very broad, more blackish stripe, this more pruinose behind and with indications of a paler median line in the holotype specimen; lateral stripes lacking or fused with the central discal area; posterior sclerites of notum dark grey. Pleura grey, vaguely patterned with darker grey. Halteres with stem pale, knob darkened. Legs with coxae dark, pruinose; trochanters light brown; femora yellowish brown to pale brown, unvariegated; tibiae and tarsi darker brown. Wings (text-fig. 14*a*) with a weak brown tinge,



TEXT FIG. 14.—*Limonia* (*Gleranomysia*) *gravelegna*, sp. nov.; *a.*, venation; *b.*, male hypopygium.

the prearcular field yellow; stigma short-oval, pale brown; veins brown. Costal fringe dense and relatively long. Venation: *Sc* long, *Sc*<sub>1</sub> ending a short distance before fork of *Rs*, *Sc*<sub>2</sub> at its tip; *m-cu* variable in position, at the fork of *M* to almost one-half its length before this fork; supernumerary crossvein in cell *Sc* not clearly evident in type specimens.

Abdominal tergites brownish black, including the hypopygium; caudal borders of segments slightly paler; basal sternites reddish brown, the fifth and succeeding segments blackened. Male hypopygium (text-fig. 14*b*) with the ventral dististyle very long and fleshy, in area very much exceeding the basistyle; setae on surface small and sparse; rostral prolongation, *rd*, stout basally, at apex narrowed into a compressed beak, at base of which on outer margin with a single strong tubercle bearing two strongly curved spines at its apex; the tubercle is about one-third the length of the rostral prolongation beyond it and nearly one-third the length of the longest spine. Dorsal dististyle,

*dd*, an unusually long and strongly curved chitinized hook, the long drawn out tip acute. Mesal-apical lobe of gonapophysis, *g*, long and slender, gently curved, entirely pale.

*Habital*.—Eastern Himalayas (Darjiling District).

*Holotype*, ♂, Peshoke (Pashok) Spur, altitude 2,000-3,500 feet, April 23-May 11, 1915 (F. H. Gravely). *Paratopotype*, ♂.

The type material had been questionably determined by Brunetti (*Rec. Ind. Mus.* XV, p. 287, 1918) as being *Limonia* (*Geranomyia*) *genitalis* (Brunetti), which is identical with *L. (G.) fletcheri* (Edwards), both originally described in 1911 but with *fletcheri* having a slight priority. The present fly is entirely distinct from *fletcheri*, differing in all details of colouration of the body and wings, and especially in the structure of the male hypopygium. *L. (G.) fletcheri* has the rostral spines of the male hypopygium short and straight, from a short tubercle, the prolongation beyond them short and obtuse. I am very pleased to dedicate this fly to the collector, Dr. F. H. Gravely.

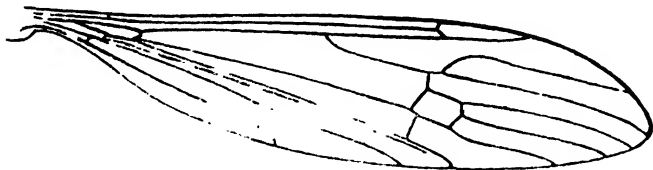
### ***Helius (Helius) boops*, sp. nov.**

General colouration of mesonotum dark brown, the sides of the praescutum broadly obscure yellow; knobs of halteres dark brown; wings subhyaline, sparsely patterned with brown; costal fringe and macrotrichia of veins short; *Rs* relatively long; cell 1st  $M_2$  rectangular, with *m-cu* at near one-fourth to one-fifth its length; abdominal tergites reddish brown, sternites more yellow.

*Female*.—Length, including rostrum, about 8.6 mm.; wing 7.3 mm.; rostrum 0.6 mm.

Rostrum brown, subequal in length to the remainder of head; palpi dark. Antennae dark brown, broken beyond the base, the first flagellar segment a little shorter than the scape. Head brownish grey; eyes large; anterior vertex reduced to a narrow strip that is about one-half the diameter of scape.

Pronotum dark brown. Mesonotal praescutum dark brown medially, the broad lateral portions more obscure yellow, the lateral margins behind the pseudosutural foveae restrictedly more darkened; posterior



TEXT-FIG. 15.—*Helius (Helius) boops*, sp. nov.; venation.

sclerites of notum dark brown, the median region of scutum pale. Pleura pale reddish brown, the meral and dorsopleural regions paler. Halteres with stem yellow, knob dark brown. Legs with coxae brownish yellow to yellow; trochanters yellow; remainder of legs broken. Wings (text-fig. 15) subhyaline restrictedly patterned with brown, as follows: Arculus; origin of *Rs*; cord and outer end of cell 1st  $M_2$ ; the narrow wing-tip; stigma oval, slightly darker brown; veins dark brown. Com-

pared with *longinervis*, costal fringe and macrotrichia of veins shorter ; wings longer and narrower, more pointed at apex. Venation : *Rs* relatively long ; *r-m* connecting with *Rs* about one-half its length before fork ; cell 1st  $M_2$  more rectangular than in *longinervis*, *m-cu* at near one-fourth to one-fifth the length.

Abdominal tergites reddish brown ; sternites more yellow ; a narrow dark pleural stripe ; bases of ovipositor obscure yellow.

*Habitat*.---Assam (Khasi Hills).

*Holotype*, alcoholic ♀. Stream below Power House, Shillong, altitude about 5,000 feet, December 5, 1930 (H. S. Rao).

The nearest ally of the present fly is *Helius* (*Helius*) *longinervis* Edwards (Pahang-Java) which differs from the present species especially in colouration, venation and in the much longer macrotrichia of the wing veins. Edwards refers his species to the subgenus *Eurhamphidia* Alexander and from the position of the *r-m* crossvein before the fork of *Rs*, this assignment may well be more correct despite the very different general appearance of *longinervis* and *boops* from the normal type of *Eurhamphidia*.

### Tribe PEDICIINI.

#### **Dicranota (Rhaphidolabis) sordida** (Brunetti).

1911. *Cladurooides sordida*, Brunetti, *Rec. Ind. Mus.* VI, p. 290.

1912. *Rhaphidolabis indica*, Brunetti, *Fauna Brit. India, Dipt. Nemat.*, p. 519, pl. x, fig. 15.

Punjab, Dalhousie, stream next to Punj-pul Nallah, altitude 6,500 feet, May 8, 1927 (S. L. Hora) ; Dalhousie, round about Hurst Cottage, Bakrota Hill, altitude 7,000 feet, May-June 1927 (S. L. Hora). Brunetti's types were from Simla and vicinity. Without an actual study of the holotype, the present determinations are as safe as is possible.

### Tribe HEXATOMINI.

#### **Limnophila raoana**, sp. nov.

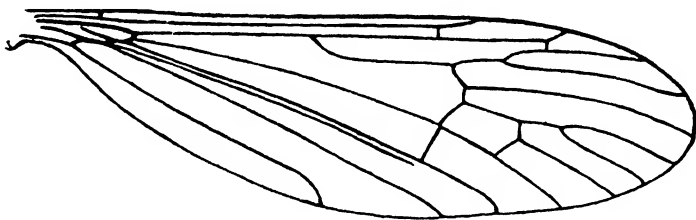
General colouration of head, thorax and abdomen dark brown to brownish black ; antennae with scape and pedicel black, flagellum brown ; flagellar segments provided with an abundant pale pubescence and elongate verticils ; anterior vertex wide ; halteres black throughout ; femora black, the tips narrowly but abruptly and conspicuously yellow ; tibiae and tarsi yellow ; legs provided with long conspicuous setae ; wings with the very restricted ground, whitish subhyaline, very heavily patterned with brown, especially dense in the radial field where the ground is reduced to linear transverse dashes ; *Sc* long ;  $R_{2+3+4}$  unusually long, about one-third *Rs* ; *m-cu* very close to the fork of *M* ; cerci black, the tips paling to horn-yellow.

*Female*.—Length about 8.5 mm. ; wing 7.7 mm.

Rostrum and palpi black. Antennae with scape and pedicel black, flagellum brown ; scape elongate ; pedicel relatively stout, about twice as long as thick ; flagellar segments subcylindrical to elongate-oval, with truncate ends, provided with a dense erect pale pubescence and

elongate verticils, the longest of these latter unilaterally distributed, exceeding the segments in length. Head with anterior vertex wide, exceeding twice the diameter of scape; eyes protuberant (possibly due to the position in mounting), with relatively coarse ommatidia; head dark brown.

Thorax almost uniform dark brown, the praescutum without distinct stripes; setae of praescutal interspaces sparse but elongate, black. Pleura uniformly dark brown. Halteres black throughout. Legs with coxae brownish black; trochanters dark brown; femora black, the tips narrowly but abruptly and conspicuously yellow; tibiae and tarsi yellow, the terminal tarsal segments darkened; legs with very long coarse setae, black on the femora, yellow on the tibiae and tarsi; tibial spurs black, long and conspicuous, hairy; claws slender, simple. Wings (text-fig. 16) with the very restricted ground colour, whitish subhyaline,



TEXT FIG. 16.—*Limnophila raoana*, sp. nov.; venation.

chiefly obliterated by unusually heavy brown markings, in the radial field restricting the pale ground to linear transverse lines and dashes; in cells basad of cord and in outer medial and cubital fields the pale ground areas more numerous, more nearly equal in extent to the dark spots; two major dark spots along vein 2nd  $A_1$ , one at apex, the second beyond midlength; cells  $C'$  and  $Sc$  with series of dark spots and dashes; veins dark brown,  $C'$  pale yellow except where variegated by dark dashes. Costal fringe moderately long and conspicuous. Venation:  $Sc$  long,  $Sc_1$  ending about opposite midlength of  $R_{2+3+4}$ ,  $Sc_2$  a short distance removed from its tip;  $Rs$  arcuated at origin, nearly three times the long  $R_{2+3+4}$ ;  $R_{1+2}$  relatively short, from one-third to one-half times  $R_{2+3}$ ; cell  $M_1$  about twice its petiole; cell 1st  $M_2$  rectangular, with  $m-cu$  very close to the fork of  $M$ , in one wing about one-fifth its length beyond the fork, in the opposite wing even closer to the fork; anterior arculus present; vein 2nd  $A$  elongate, extending generally parallel to the anal border of wing.

Abdomen brownish black to black, the genital segment narrowed; valves of ovipositor blackened, the distal half of cerci paling to horn-yellow; cerci long and slender, gently upcurved.

*Habitat.*—Bombay Presidency (North Kanara District).

*Holotype*, ♀. Hill stream on Jog-Sagar Road, November 30, 1928 (H. S. Rao).

This distinct species is named in honour of the collector, Dr. H. S. Rao. There are several allied forms in the Oriental fauna, including *Limnophila bivittata* Edwards, *L. multipunctata* Brunetti, *L. pendleburyi* Edwards and *L. senior-whitei* Alexander. The present fly differs

from all of these by the colouration of the body and legs, by the unusually heavy dark pattern of the wings, and by the position of *m-cu* close to the fork of *M*, in this latter respect suggesting species of the genus *Dactylolabis* Osten Sacken. I had formerly believed that certain of these species more properly fell in *Pseudolimnophila* Alexander but since the anterior arculus is preserved in all and other characters fail to agree, it seems best to place them all in *Limnophila* Macquart until the Oriental species of the group are better known.

***Limnophila manipurensis*, sp. nov.**

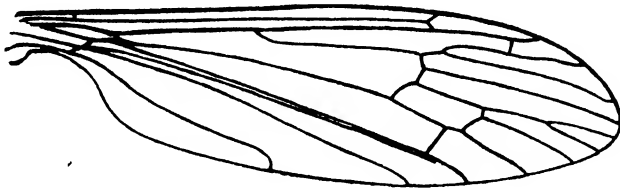
General colouration dark, sparsely grey pruinose; praescutum with three darker brown stripes; scutellum with a dark median vitta; antennae short, basal segments short and crowded, flagellum yellow; halteres obscure yellow; legs with femora yellow, the tips rather narrowly blackened; tips of tibiae narrowly darkened; legs provided with long conspicuous setae; wings yellow, spotted and very abundantly dotted with brown; *R*<sub>2</sub> very faint, placed near midlength of the pale yellow stigma; *m-cu* lying very far distad, about four-fifths the length of cell 1st *M*<sub>2</sub>.

*Female*.—Length about 10 mm.; wing 10 mm.

Rostrum and palpi brown. Antennae with scape black, relatively short; pedicel dark brown; flagellum obscure yellow, the outer segments more darkened; antennae short, basal flagellar segments short and crowded, the first flagellar segment with a short basal pedicel, the succeeding segments closely applied to one another; fifth and following segments becoming more elongate and provided with long verticils, on the outer segments being nearly three times as long as the segments themselves; terminal segment elongate, exceeding twice the penultimate. Head dark brown.

Pronotum dark brown, relatively massive. Mesonotal praescutum brownish grey, with three somewhat conspicuous brown stripes, the median one more or less divided by a pale central line, narrowed and entire before the suture; lateral stripes more distinct and more or less confluent at their anterior ends with the median vitta, obliterating the interspaces at this point; suture conspicuously darkened medially; scutum grey each lobe variegated with a dark brown area, the broad median region with vague indications of a capillary dark line; scutellum dark grey, with a conspicuous median brown vitta, parascutella dark; postnotum dark grey, the mediotergite more darkened posteriorly. Pleura chiefly brownish black, more or less pruinose. Halteres obscure brownish yellow, the knob weakly darkened. Legs with the coxae dark brown; trochanters brownish yellow; femora yellow, the tips rather narrowly but conspicuously blackened; tibiae yellow, the tips very narrowly dark brown; tarsi yellow, the tips of the first three segments narrowly and vaguely darkened; terminal two segments darkened; legs with long conspicuous setae, especially long and outspreading on tibiae and tarsi; tibial spurs elongate. Wings (text-fig. 17) with the ground colour yellow, spotted and very abundantly dotted with brown; major dark areas at origin of *R*s; along cord, beginning as a relatively small spot at proximal end of the otherwise pale stigma;

smaller dark marginal areas at ends of veins  $R_3$  and  $R_4$ ; the brown dots include all cells, in the outer and posterior fields somewhat larger



TEXT FIG. 17.—*Linnophila manipurensis*, sp. nov.; venation.

and tending to become confluent; tip of vein *2nd A* with a small darkened area; veins yellow, darker in the patterned areas. Costal fringe relatively long and abundant but subappressed. Venation: *Sc* long,  $Sc_2$  longer than  $Sc_1$ , ending a short distance before end of  $R_{2+3+4}$ ;  $R_2$  very faint to subatrophied, at near midlength of the pale stigma; cell  $M_1$  subequal in length to or a little shorter than its petiole; *m-cu* lying unusually far distad, about four-fifths the length of the cell, the distal section of  $M_{3+4}$  only about one-half *m-cu* and much shorter than the basal section of  $M_3$ ; cell *2nd A* wide; anterior arculus preserved.

Abdomen dark brown, indistinctly variegated with more reddish areas; genital segment dark; valves of ovipositor horn-yellow; cerci elongate, only gently upcurved near tips, the latter acute.

*Habitat*.—Assam (Manipur).

*Holotype*, ♀, Thanga Island, Loktak Lake, at light, February 1920 (Manipur Survey).

*Linnophila manipurensis* is readily separated from other related forms listed under the preceding species by the details of colouration of the body, legs and wings, and especially by the venation, in the unusual position of *m-cu* far out toward the end of cell *1st M*<sub>2</sub>.

### Tribe ERIOPTERINI.

#### **Teucholabis (Teucholabis) angusticapitis** Brunetti.

1918. *Teucholabis angusticapitis*, Brunetti, *Rec. Ind. Mus.* XV, p. 305, pl. viii, fig. 11 (head).

1919. *Teucholabis nocticolor*, Edwards, *Journ. Fed. Malay States Mus.* VIII, pp. 18, 19, pl. iii, fig. 6 (hypopygium); pl. iv, fig. 13 (wing).

The Holotype, ♂, Regd. No. 8520/H2, was from above Tura, Garo Hills, Assam, altitude 3,500-3,900 feet, August 1917 (S. W. Kemp).

*Male*.—Length about 7 mm.; wing 7.6 mm.

Head long and narrow, as mentioned by Brunetti; rostrum more than one-half the remainder of head. Antennae dark brown. Head pruinose.

Pronotum relatively conspicuous. Thorax blackish, the cephalic portion of praescutum paler, more reddish brown. Pleura and postnotum sparsely pruinose. Halteres dusky, including the knobs. Legs blackish, with relatively conspicuous black setae. Wings blackish, with two narrow whitish crossbands, as described. Venation: *Sc*

relatively long,  $Sc_1$  ending a short distance before the fork of  $R_s$ ;  $R_s$  relatively short, straight;  $R_2$  a little shorter than  $R_{2+3+4}$ ; cell  $1st\ M_2$  relatively small, subrectangular, shorter than vein  $M_3$  beyond it;  $m-cu$  nearly its own length beyond fork of  $M$ , only about one-fourth the length of distal section of  $Cu_1$ .

Abdomen black throughout; sternal pocket present.

Edwards (*Rec. Ind. Mus.* XXVI, p. 300, 1924) places his *nocticolor* as a synonym of *angusticapitis*. It should be noted in this insect as well as in most others described by Brunetti that his measurements of the body length are under the actual dimensions.

### **Teucholabis (Teucholabis) pruthiana, sp. nov.**

General colouration of mesonotum polished black, the humeral region of praescutum, the suture, the broad median region of scutum and the scutellum yellow; pleura black, the dorsal sternopleurite and meral region yellow; femora yellow, the tips broadly black, most extensive on the fore legs; wings yellow, restrictedly patterned with pale brown and darker brown, including a broken crossband at level of origin of  $R_s$  and a complete band at the cord; wing-tip broadly paler brown; abdomen dark brown, the incisures rather narrowly yellow; subterminal segments uniformly yellow, the styli of hypopygium dark; male hypopygium with the outer dististyle simple; inner dististyle with two arms that terminate in blackened points.

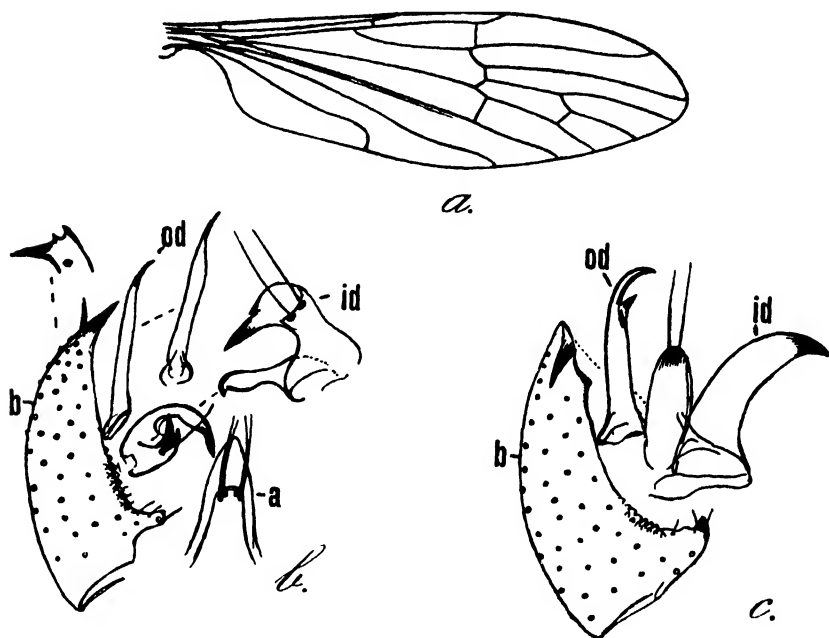
*Male*. Length about 7.5 mm.; wing 6.5 mm.

Rostrum black, relatively long and slender, subequal in length to remainder of head; palpi and mouthparts black. Antennae black; basal flagellar segments short-oval, the segments passing through oval, the outer ones long oval; verticils subequal in length to the segments. Head black.

Pronotum orange yellow. Mesonotal praescutum polished black, the humeral triangles extensively yellow, the suture and vicinity more narrowly but continuously yellow; scutum with lobes polished black, the broad median area and the scutellum yellow; parascutella black; postnotum black. Propleura black. Mesopleura broadly black above and on the ventral sternopleurite, the dorsal sternopleurite and meral region yellow, the pleurotergite and metapleura black. Halteres with stem blackened, knob light yellow. Legs with coxae and trochanters yellow; femora yellow, the tips broadly blackened, on the fore pair including about the distal two-fifths, narrower on the middle and posterior legs where the outer fourth to fifth is blackened; tibiae dark brown, the tips narrowly blackened; tarsi black. Wings (text-fig. 18a) with the ground colour yellow, restrictedly patterned with pale brown and darker brown, the darker areas appearing as a broken crossband at level of origin of  $R_s$ , including dark clouds at origin of  $R_s$  and end of vein  $2nd\ A$ , the band much paler brown in the intervening cells; a second dark band at cord, beginning at the oval, darker brown stigma, extending to vein  $Cu$ ; the paler brown areas include the broad wing apex and narrower posterior margin, the former extending basad to the general level of outer end of cell  $1st\ M_2$ , the latter including the outer ends of cells  $M_4$  to  $2nd\ A$ , inclusive, the base and axillary region remaining pale; cell



C yellow, Sc brown; veins brown. Costal fringe relatively short and dense. Venation: Sc of moderate length,  $Sc_1$  ending near two-fifths the length of Rs,  $Sc_2$  a little closer to origin of Rs than to tip of  $Sc_1$ .



TEXT FIG. 18.—*Teucholabis (Teucholabis) pruthiana*, sp. nov.; a., venation; b., male hypopygium; c., male hypopygium of *T. (T.) annuloabdominalis* Senior-White (right) shown for comparison.

Abdomen dark brown, the incisures rather narrowly yellow, including the narrow apical borders of the segments and the subequal extreme base of the succeeding segments; segments eight and nine yellow, the styli of the male hypopygium brownish black. Sternal pockets well-developed, especially the major one on fifth segment; this latter pocket is much larger than in *annuloabdominalis*, occupying most of the width of the segment, with the setae more numerous and differently distributed. Male hypopygium (text-fig. 18b) with the apical lobe of basistyle, b, bispinous; mesal flange consisting of numerous low triangular points and interpolated setae, at cephalic end of flange produced into a more elongate lobe. Outer dististyle, od, a simple slender rod, the narrowed tip acute. Inner dististyle, id, bifid; the arm bearing the two elongate setae produced into two blackened spinous points, the more elongate simple arm more or less narrowed to a blackened point. Aedeagus, a, bearing four elongate setae on shorter lobe.

In *annuloabdominalis* (text-fig. 18c), the apical lobe of basistyle, b, extended into a single spine. Outer dististyle, od, stouter, the apical spine gently curved, bearing a shorter lateral spine before apex. Inner dististyle, id, of entirely different conformation, the arm bearing the two elongate setae shorter, simple, obtuse at apex; simple arm longer, appearing as a cultriform blade, the acute apex blackened.

*Habitat*.—South India (Palni Hills).

*Holotype*, ♂, Muliar, below Kodaikanal, altitude about 5,000 feet, July 1-3, 1929 (H. S. Pruthi); Eastern Ghats Survey.

I take very great pleasure in dedicating the species to the collector, Dr. Hem Singh Pruthi. The nearest ally is *Teucholabis* (*Teucholabis*) *annuloabdominalis* Senior-White, of Ceylon, which differs in the details of colouration of the thorax, legs and wings, in the broader yellow abdominal rings, and, especially, in the structure of the male hypopygium.

***Gonomyia* (*Lipophleps*) *ornatipes* (Brunetti).**

1912. *Dicranomyia ornatipes*, Brunetti, *Fauna Brit. India, Dipt. Nemat.*, p. 380, pl. vii, fig. 10 (wing).

One ♂ Coimbatore, South India. September 2, 1938 (Susai Nathan); one ♂ Nedungadu, Tanjore District, February 17, 1938 (Susai Nathan). Edwards had considered this species as being a synonym of the earlier described East Indian *Gonomyia* (*Lipophleps*) *pilifera* (de Meijere), but in my opinion the two flies are quite distinct though belonging to the same group of species which has been named the *pilifera*-group.

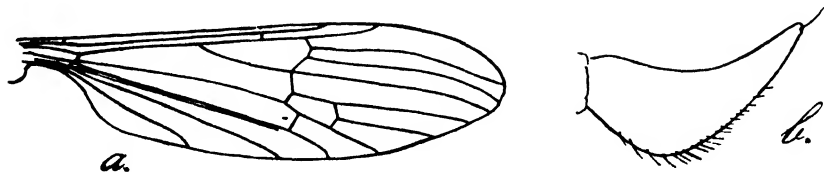
***Gnophomyia* (*Gnophomyia*) *klossiana*, sp. nov.**

General colouration dark brown; pleura brownish black, the ventral pteropleurite and meral region more brownish yellow; antennae relatively elongate, black; legs dark brown to brownish black; wings with a weak brown tinge, the large diffuse stigma conspicuously darker brown; *Rs* in direct longitudinal alignment with  $R_5$ ; *r-m* at end of *Rs*;  $R_{2+3+4}$  unusually erect,  $R_{2-3}$  subperpendicular, only a little longer than  $R_2$  alone; cell  $R_2$  at margin very extensive, approximately six or seven times as wide as cell  $R_3$ ; cell 1st  $M_2$  relatively small; abdominal tergites brownish black; ovipositor yellow, the cerci strongly compressed.

*Female*.—Length about 5 mm.; wing 5.4 mm.

Rostrum and palpi black. Antennae with scape and pedicel dark brown; flagellum black; flagellar segments cylindrical, relatively elongate in the female sex; longest verticils nearly equal in length to the segments, appressed. Head brownish black.

Mesonotum almost uniformly dark brown. Pleura chiefly blackened, the propleura, ventral pteropleurite and meral region more brownish yellow; pleurotergite brownish black. Halteres with stem dusky, knob dark brown. Legs with coxae and trochanters reddish brown;



TEXT FIG. 19.—(*Gnophomyia* (*Gnophomyia*), *klossiana*, sp. nov.; a., venation; b., ovipositor.

remainder of legs dark brown to brownish black; tarsi considerably shorter than tibiae. Wings (text-fig. 19a) with a weak brownish tinge,

the large diffuse stigma conspicuously dark brown: veins dark brown. Costal fringe long and conspicuous. Venation;  $R_s$  in direct longitudinal alignment with  $R_5$ ;  $R_{2+3+4}$  unusually erect,  $R_{2+3}$  even more so, only a little exceeding  $R_2$  alone;  $r-m$  at end of  $R_s$ ; veins  $R_3$  and  $R_4$  unusually long and extending generally parallel to one another, the cell being a trifle wider about midlength; cell  $R_2$  at margin very extensive, being from six to seven times that of cell  $R_3$ ; cell  $1st\ M_2$  relatively small, subequal in length to vein  $M_4$  beyond it;  $m-cu$  about one-third the length of cell  $1st\ M_2$ ; cell  $2nd\ A$  of moderate width only.

Abdominal tergites brownish black, the basal sternites more reddish brown. Ovipositor (text-fig. 19b) with the cerci light yellow, appearing as very compressed blades, widest on basal half, the upcurved distal portion strongly narrowed, the ventral margin with long setae.

*Habitat*.—Federated Malay States (Selangor-Pahang Boundary).

*Holotype*, ♀, Ginting Bidai, altitude 2,000 feet, April 1917 (C. Boden Kloss).

From the numerous oriental species of the genus that center about *Gnophomyia* (*Gnophomyia*) *orientalis* de Meijere and *G. (G.) strenua* Brunetti, the present fly is most readily told by the venation, especially the unusually precipitous veins  $R_{2+3+4}$  and  $R_{2+3}$ , and by the unusual marginal extent of cell  $R_2$ . The strongly compressed-flattened ovipositor is likewise somewhat different from the usual type found in the genus.

### ***Styringomyia kempiana*, sp. nov.**

General colouration dark grey, the praescutum bordered in front and on sides by a narrow black line; pronotum, posterior border of scutellum and a capillary median vitta on postnotum obscure yellow; pleura black, sparsely pruinose; halteres uniformly brownish black; femora brownish black, the fore and middle pair with a very narrow, obscure yellow, subterminal ring, the posterior femora with this ring much more diffuse; tibiae brownish black, the fore and middle pair with the bases and a subterminal ring obscure yellow; posterior tibiae uniformly darkened; wings with a strong brownish yellow tinge; vein  $2nd\ A$  curved to the wing margin, without angulation or spur; male hypopygium with the basistyle terminating in three strong spinous bristles; inner arm of dististyle very large, oval, provided with abundant long retrorse setae.

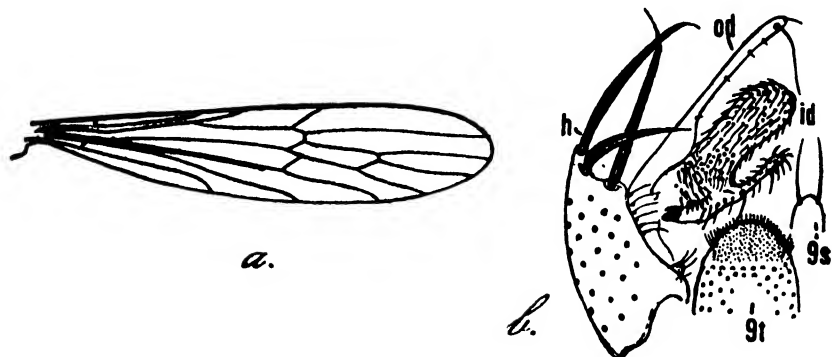
*Male*. Length about 6.5 mm.; wing 4.3-4.4 mm.

*Female*.—Length about 6 mm.; wing about 4 mm.

Rostrum and palpi black. Antennae with scape dark, grey pruinose; pedicel brown, flagellum obscure yellow, the outer segments more darkened; flagellar segments long-oval, the outer ones becoming even more attenuated; terminal segment shorter than the penultimate. Head light brown; setae delicate.

Pronotum obscure yellow, darkened and impressed medially. Mesonotum chiefly dark grey, the praescutum bordered in front and on sides by a narrow black line, the usual interspaces less distinctly darkened; posterior sclerites of notum blackened, pruinose, the scutal lobes slightly darker; posterior border of scutellum and a capillary median vitta on postnotum obscure yellow. Pleura black, sparsely pruinose. Halteres

uniformly brownish black. Legs with coxae brown; trochanters brownish yellow; femora brownish black, the bases restrictedly paler; fore and middle femora with a very narrow, obscure yellow ring placed some three times its length before the tip, the posterior femora with the ring indicated but much more diffuse; fore and middle tibiae brownish black, the very narrow bases and a narrow ring about two-thirds the length obscure yellow; posterior tibiae uniformly dark brown; tarsi brownish black, the proximal ends of basitarsi slightly paler, on the posterior legs with both the first and second segments somewhat more obscure yellow, the outer segments blackened. Wings (text-fig. 20a) with a strong brownish yellow tinge, without pattern, a little clearer



TEXT FIG. 20.—*Styringomyia kempiana*, sp. nov.; a., venation; b., male hypopygium.

in the prearcular field and just beyond; veins brown. Costal fringe long and conspicuous. Venation: Anterior branch of  $R_s$  oblique, from two to four times the basal section of  $R_5$ ; cell  $2nd\ M_2$  broadly to narrowly sessile; vein  $2nd\ A$  evenly curved into the margin, without angulation or spur.

Abdomen elongate in male; basal segments blackened, succeeding segments pale brown or brownish yellow, narrowly blackened laterally, the posterior borders of the individual segments much less distinctly so; hypopygium and preceding segments more uniformly brownish black; abdomen with long conspicuous black, setae. Female with abdomen more uniformly darkened, possibly due to discolouration; genital segment dark brown, terminating in unusually slender black lobes, each tipped with two long setae. Male hypopygium (text-fig. 20b) with the ninth tergite,  $9t$ , broad, terminating in a semicircular cushion; ninth sternite,  $9s$ , with the two terminal bristles relatively weak. Basistyle,  $b$ , terminating in three strong spinous bristles, two of which are produced into hair-like points. Outer arm of dististyle,  $od$ , entirely pale, dilated on basal third, at apex bearing one very small and one very long bristle; margin of arm with about four small setae extending to the dilated basal portion. Inner arm of dististyle,  $id$ , an oval lobe with a slender lateral arm. both with abundant long black setae, the slender arm with two more spinous bristles of larger size.

*Habitat*.—Southwest India (North Kanara District).

*Holotype*, ♂, Castle Rock, October 11-26, 1916 (S. W. Kemp).

*Allotype*, ♀, Talewadi, near Castle Rock, October 3-10, 1916 (S. W. Kemp). *Paratopotypes*, 2 broken ♂♂, with the type. Only the Holotype is in a well-preserved state.

This conspicuous species is named in honour of the collector, Dr. Stanley W. Kemp, who has added vastly to our knowledge of the insect fauna of British India. Except for the ringed tibiae, the present fly runs to the group of species including *Styringomyia flava* Brunetti and *S. solocipennis* Enderlein, all having three conspicuous spinous setae on the basistyle of the male hypopygium. It differs from all previously described species by the colouration of the body and legs, and, especially, the structure of the male hypopygium. Edwards placed *S. obscura* Brunetti in this same group of species having trispinous basistyles and in all probability it belongs to this group but since the species seems still to be known only from the unique type (a female from Nepal), it may be that the male hypopygium will not be found to conform to this group.

### ***Styringomyia susilae* sp. nov.**

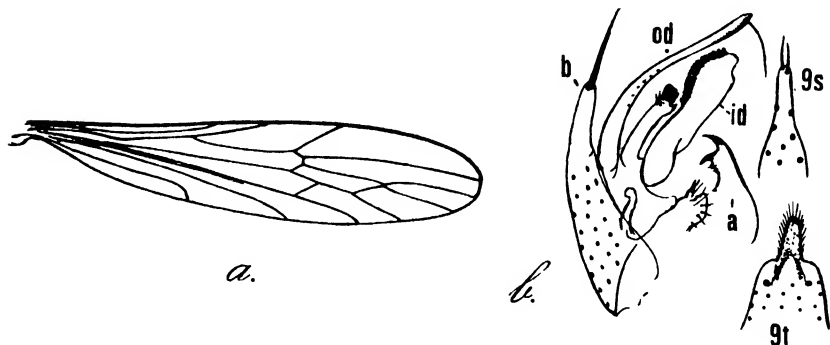
General colouration yellow, the mesonotum patterned with black, including two circular spots placed laterally on the suture; praescutum behind with a central pale line bordered laterally by black, the pale vitta continued caudad across the suture on to the scutellum; pleura uniformly pale; dark rings on legs very reduced, the posterior femora being unpatterned; all tibiae abruptly tipped with black; tarsi yellow, the terminal segment blackened; wings yellow, restrictedly patterned with dark brown, the chief area being a cloud over *r-m*; vein *2nd A* without angulation or spur; abdominal pattern pale and reduced; male hypopygium with both tergal and sternal lobes very narrow, especially the former; dististyle with inner lobe large, its margin bearing a linear series of about 18 to 20 blackened spinous points.

*Male*.—Length about 6.5-7 mm.; wing 4.4-4.6 mm.

Rostrum obscure yellow; palpi brownish yellow. Antennae with basal segments obscure yellow, the scape more or less infuscated; outer flagellar segments weakly bicoloured, the apices a little brighter yellow than the bases. Head yellow, with normal slender setae.

Pronotum and mesonotum yellow, the latter with a pale to whitish median stripe that is indicated especially by the blackened lateral borders, these becoming wider and more evident at cephalic ends, the pale median vitta crossing the suture and scutum on to the scutellum; near lateral ends of suture a conspicuous circular black spot occupies parts of both praescutum and scutum; posterior sclerites of notum chiefly brownish yellow; posterior borders of scutal lobes each with an infuscated area; pleura yellow. Halteres yellow. Legs with the coxae and trochanters yellow; femora yellow, the usual dark rings very incomplete to scarcely indicated, on fore and middle legs appearing as weak clouds on the upper surface only, on the posterior femora quite lacking; tibiae yellow, the tips of all pairs narrowly but very conspicuously black; tarsi very pale yellow to whitish yellow, only the last segment abruptly blackened, the tips of other segments not darkened. Wings (text-fig. 21a) strongly yellow, the costal border, especially in the outer radial field, more saturat-

ed yellow ; a restricted dark brown cloud at *r-m* and less distinct very narrow seams and darkenings of the veins at outer end of cell *1st M*<sub>2</sub>, *m-cu*, and distal third or more of *2nd A* ; remaining veins uniformly yellow, including their tips. Venation : Anterior branch of *Rs* normally oblique ; cell *2nd M*<sub>2</sub> very short-petiolate to narrowly sessile ; vein *2nd A* curved evenly but rather strongly into the border, not angulated or spurred.



TEXT FIG. 21.—*Styringomyia susilae*, sp. nov. ; a., venation ; b., male hypopygium.

Abdomen yellow, the dark pattern very restricted, appearing as paired brown dots at the posterior borders of the tergites, on the seventh segment with an additional median basal streak ; sternites unpatterned ; hypopygium yellow. Male hypopygium (text-fig. 21b) with the ninth tergite, *9t*, terminating in an unusually narrow apical lobe that is narrower than the lobe of the ninth sternite, this lobe provided with long abundant setae, subtended on either side by glabrous shoulders. Ninth sternite, *9s*, long and narrow, the setae relatively weak, one placed slightly more distad than the other. Basistyle, *b*, terminating in a long lobe that bears a single strong spinous seta that is subequal in length to or a trifle longer than the lobe itself. Dististyle with outer arm, *od*, slender, strongly blackened along lower border at tip ; setae two, the outer one unusually reduced, the longer seta of normal length ; face of arm with six or seven scattered setae but with no spinous points ; intermediate and inner arms of dististyle as figured, the intermediate arm more slender but elongate, tipped with six to eight short but strong black spines in a compact mass, with a group of normal setae immediately basad ; inner arm, *id*, a little longer and wider, appearing as a flattened blade, the outer margin with a row of blackened blunt-tipped spines, totalling 18 to 20, arranged in a close linear series. Aedeagus, *a*, terminating in two pairs of blackened acute spinous points.

*Habitat*.—South India (Southern Malabar).

*Holotype*, ♂, Walayar Forest, altitude 2,000 feet, August 8, 1938 (Susai Nathan). *Paratopotypes*, several ♂♂ with the type. Paratypes in collection of Indian Museum.

I am pleased to name this species after Miss Susila Nathan, the infant daughter of Mr. Susai Nathan, to whom I am indebted for several interesting species of Tipulidae from Malabar. By Edwards' key to the then known species of the genus (*Trans. Ent. Soc. London*, pp. 210-212, 1914)

*Styringomyia susilae* runs to *S. jacobsoni* Edwards, of Java, a very different species. The slenderness of the simple apical lobe of the ninth tergite suggests *S. fryeri* Edwards, which is likewise entirely distinct from the present fly. The chief characteristics for the separation of *susilae* from its allies, aside from hypopygial differences, lie in the very reduced dark pattern of the legs and in the somewhat peculiar pattern of the mesonotum.

## CYCLOPIDES (CRUSTACÉS COPÉPODES) DE L'INDE. XI-XIII.

Par KNUT LINDBERG.

### XI. CONTRIBUTION À LA CONNAISSANCE DE *CYCLOPS* (*MICROCYCLOPS*) *VARICANS* Sars ET *CYCLOPS* (*MICROCYCLOPS*) *LINJANTICUS* KIEFER.

#### *Cyclops* (*Microcyclops*) *varicans* Sars.

Dans ma revision en 1939 des représentants indiens du sous-genre *Microcyclops* j'avais cru devoir maintenir le *C. (M.) varicans subaequalis*

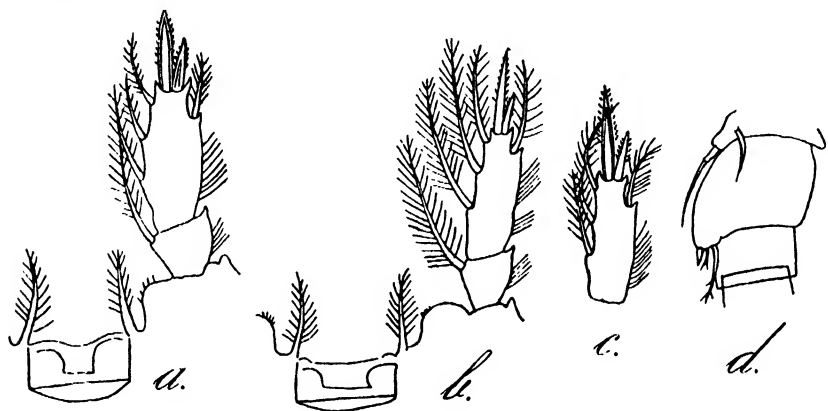


FIG. 1.—*Cyclops* (*Microcyclops*) *varicans* (Sars).

a. ♀ Endopodite et lamelle basale de P 4. (Suse); b. ♀ Endopodite et lamelle basale de P 4 (Tang-Qil); c. ♀ Article 2 de l'endopodite de P 4 (Chahi); d. ♂ P 5 et P 6 (Chah).

comme une sous-espèce ou variété de *C. (M.) varicans* par suite de la structure de l'épine apicale interne de l'article terminal de l'emp. 4, celle-ci ne présentant pas de renflement à sa base et étant en général plus allongée par rapport à la longueur de l'article que chez le *C. (M.) varicans* typique. De plus, les animaux indiens offrant ces caractéristiques possédaient un article de P 5 muni d'une petite épine sur le rebord interne.

Parmi les *C. (M.) varicans* récoltés dans plusieurs localités différentes de l'Iran, certains ont été du type *varicans* et d'autres ont répondu au diagnostic de la variété *subaequalis*, en ce qui concerne la structure de l'article terminal de l'emp. 4 et de ses appendices, mais sans qu'il y ait eu de séparation tranchée entre les deux formes. Comme d'ailleurs tous les animaux examinés ont présenté un article de P 5 de configuration identique, et que je n'ai chez aucun d'eux aperçu d'épine sur le rebord interne, je ne crois plus justifié à conserver le *C. (M.) varicans subaequalis* comme une variété distincte. Les mensurations les plus importantes sont données de 22 femelles et de 4 mâles.



*Habitats*.—Inde : Semble réparti dans toute l'étendue de la péninsule.

Iran Nord : Chahi, mare eutrophique, fosse près du fleuve Talar, rizière ; Gorgan, mare sans végétation, bassin ; Lahidjan, rizière, étang eutrophique à l'Institut agricole ; Ramsar, petit étang ; Recht, mare, ruisseau ; Sari, rizière, fosse d'excavation du chemin de fer.

Iran Sud : Chouch (Suse), fosse et citerne près de la gare ; marécage près du village ; Dihak, source ; Tang-Qil, mare de rivière.

**Cyclops (Microcyclops) linjanticus** (Kiefer).

Syn. *Cyclops (Microcyclops) tricolor* Lindberg.

En étudiant l'espèce qu'en 1937 j'ai nommée *C. (M.) tricolor* je me suis rendu compte de sa ressemblance avec le *C. (M.) linjanticus* décrit

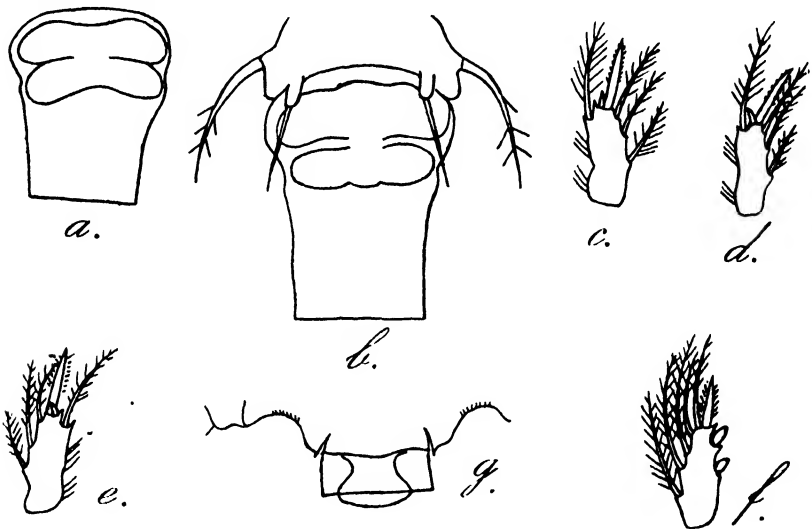


FIG. 2.—*Cyclops (Microcyclops) linjanticus* (Kiefer). ♀.

a. Réceptacle séminal, aspect commun (Réchir); b. Réceptacle séminal, aspect inusité (Recht); c. Article 2 de l'endopodite de P 4 (Recht); d. Article 2 de l'endopodite de P 4 (Réchir); e. Article 2 de l'endopodite de P 4, apparence lancéolée de l'épine apicale interne (Pahlévi-Ghazian); f. Article 2 de l'endopodite de P 4, apparence lancéolée des épines (Pahlévi-Ghazian); g. Lamelle basale de P 4 (Recht).

par Kiefer en 1928, qui cependant ne m'était connu que par les notes données dans le "Tierreich" (1929). En me basant sur cette description il ne m'a pas été possible d'identifier mes animaux avec le *C. (M.) linjanticus*. Dernièrement j'ai eu accès à deux études plus récentes publiées en 1933 et 1938 dans lesquelles Kiefer, utilisant un matériel plus abondant provenant des îles de la Sonde et de Formose, a apporté, des amplifications et des modifications assez considérables à sa description originale de *C. (M.) linjanticus*. A la lumière de cette redescription et des figures qui l'accompagnent je me crois à présent justifié à considérer le *C. (M.) tricolor* comme identique avec le *C. (M.) linjanticus* nonobstant le fait que certains désaccords subsistent encore.

Au cours de mes derniers voyages en Iran j'ai rencontré cette espèce en petit nombre dans 7 localités (4 du Sud, 3 du Nord) et je donne des mensurations de quelques uns de ces animaux.

*Habitats.* — Inde : Paraît avoir une répartition générale.

Iran Nord : Lahidjan, étang à l'Institut agricole ; Pahlévi-Ghazian, étang ; Recht, mare ; Sari, bassin.

Iran Sud : Dihak, source d'eau douce dans les montagnes entre Darol-Mizan et Kourdéh (région comprise entre Firouzabad et Djam) ; Réchir (Richehr) près de Bouchir, puits d'eau douce ; rivière d'eau douce entre Djam et Makkou.

## XII. REMARQUES SUR QUELQUES MEMBRES DU SOUS-GENRE *TROPOCYCLOPS* Kiefer.

En étudiant il y a quelques années des *Tropocyclops* de l'Inde, à formule des épines de 3-4-4-3 j'avais trouvé qu'ils différaient notablement de *E. (T.) prasinus* (Fischer) tel qu'il a été décrit en Europe. Chez les animaux indiens la furca, à branches divergentes, était considérablement plus longue (rapport moyen 3.29 : 1) ; la soie apicale médiane interne seulement de 3 à 4 fois aussi longue que la branche de la furca (rapport moyen 3.59 : 1) l'épine apicale interne de l'article 3 de l'emp. 4 le plus souvent un peu plus de 2 fois aussi longue que l'article, tandis que cette épine n'en atteint pas 2 fois la longueur chez *E. (T.) prasinus* ; enfin la cinquième patte avait une structure bien différente, possédant une épine comparativement très courte. Comme évidemment les spécimens de l'Inde représentaient une forme distincte de *E. (T.) prasinus* (Fischer) je les avais décrit comme appartenant à une espèce nouvelle que j'avais nommée *E. (T.) multicolor*.

Des *Tropocyclops* à formule des épines de 3-4-3-3 se sont montrés beaucoup moins fréquents dans les régions de l'Inde où mes pêches ont été faites. J'ai pu les référer tous sans difficulté à l'espèce *E. (T.) confinis* Kiefer. (La distinction d'une forma *frequens*, différant seulement dans ce qu'elle présente un article 3 de l'emp. 4 plus court, n'est plus justifiée, ce que Kiefer a fait observer lui-même en 1934).

Dans un article paru en 1930 Lowndes a attiré l'attention sur le fait que des *Tropocyclops* récoltés en Ethiopie, à formule des épines de 3-4-3-3, ne possédaient pas de soie au niveau de l'angle interne du deuxième article basal de P 1, une forte soie étant présente à cet endroit chez les animaux d'Europe à formule des épines de 3-4-4-3. Après avoir pris connaissance de ce travail j'ai examiné des animaux indiens à cet égard et j'ai trouvé que les *E. (T.) multicolor* à formule des épines de 3-4-4-3 possédaient bien cette soie, mais qu'elle manquait chez les *E. (T.) confinis*, qui appartiennent au groupe des " terni ".

Ayant rapporté des *Tropocyclops* de 5 localités du Sud de l'Iran, pays dans lequel aucun représentant de ce sous-genre n'était connu jusqu'à présent, j'ai pensé que l'étude de ces animaux pourrait apporter quelques faits d'intérêt général. Il s'est trouvé que tous les animaux, sauf un seul, répondaient assez bien aux caractéristiques de *T. confinis* ; l'exception était une femelle unique aberrante, qui cependant, sans aucun doute, doit être considérée comme une *T. prasinus* tératologique.

***Eucyclops (Tropocyclops) prasinus* (Fischer).**

Un seul spécimen récolté; une femelle d'une longueur de 852  $\mu$  (sans soies apicales). Furca à branches parallèles, 2 et demi fois aussi

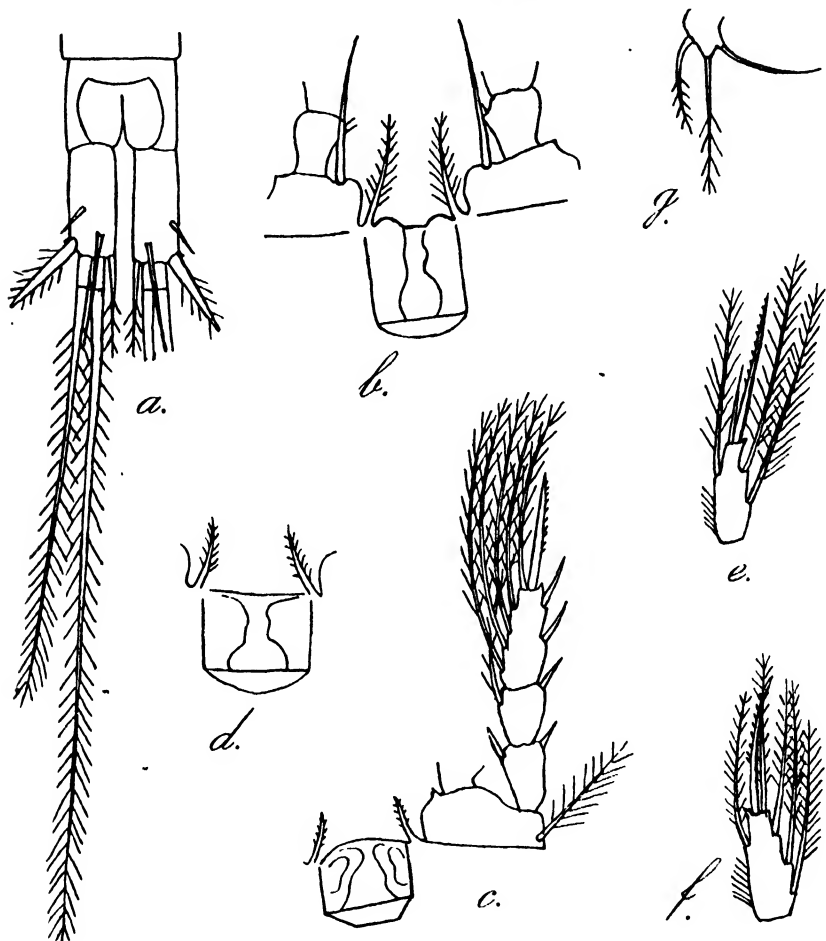


FIG. 3.—*Eucyclops (Tropocyclops) prasinus* (Fischer). ♀.

a. Furca, face dorsale; b. Lamelle basale de P 1; c. Lamelle basale et exopodite de P 3 (côté gauche); d. Lamelle basale de P 4; e. Article 3 de l'endopodite de P 4 (côté droit, face dorsale); f. Article 3 de l'endopodite de P 4 (côté gauche, face ventrale); g. P 5.

longues que larges. Soie dorsale ciliée considérablement plus longue que la soie apicale externe. Soie apicale médiane interne 6 fois aussi longue que la branche de la furca. Soie apicale externe et soie apicale interne de longueur à peu près égale. Première antenne à 12 articles, atteignant le milieu du cinquième segment thoracique. Formule des épines de 3-4-4-3 du côté droit, et de 3-4-3-3 du côté gauche. Forte et longue soie au niveau de l'angle interne du deuxième article basal de la première paire de pattes. Article 3 de l'endopodite de P 4 a un aspect normal du côté droit. Il est plus de 2 et demi fois aussi long que large et porte deux épines apicales dont l'interne est 2 fois plus longue

que l'externe et l'épine apicale interne beaucoup plus longue que l'article lui-même. Du côté gauche l'article 3 de l'endopodite de P 4 est téra-tologique. Au lieu de 2 soies il porte sur le rebord interne 3 soies ; l'épine apicale interne est remplacée par une longue soie et au lieu d'une courte et mince épine apicale externe il y a une longue et forte épine barbelée qui égale presque en longueur celle de la soie apicale interne. Article 2 de l'enp. 4 montrant aussi une structure asymétrique en comparant les deux côtés. A droite, longueur : largeur, 40 :  $25\mu=1.60 : 1$  ; à gauche, 33 :  $27\mu=1.22 : 1$ . P 5 à longue et mince épine interne. Longueur des 3 appendices du dedans au dehors respectivement 42 : 70 :  $50\mu$ . Le réceptacle séminal n'a pas pu être distingué d'une façon satisfaisante. Ovisacs appliqués contre l'abdomen, atteignant le tiers antérieur de la furca. Ils contenaient 10 et 12 oeufs.

*Habitats.*—Une mare d'eau saumâtre à surface couverte d'une couche épaisse d'algues vertes, à Mansouriyéh, village à 6 kilomètres au nord-est de Béhbéhan. L'unique spécimen qui vient d'être décrite a été récolté en février dans cette mare, en compagnie d'assez nombreux *C. (M.) minutus* Claus, de plusieurs *C. (M.) planus* Gurney et d'un seul *E. serrulatus* Fischer. Il m'a semblé être un fait exceptionnel de trouver un *Tropocyclops* dans ce genre de biotope ; presque tous les animaux de ce sous-genre que j'ai récoltés dans l'Inde et dans l'Iran ayant été pêchés dans de l'eau claire, surtout dans des puits, des citernes et des mares de rivières:

### **Eucyclops (*Tropocyclops*) confinis Kiefer.**

Les spécimens de l'Iran à formule des épines de 3-4-3-3 ont différé légèrement à certains égards des animaux correspondants de l'Inde.

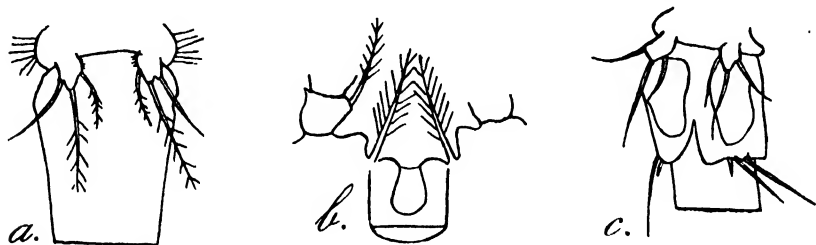


FIG. 4.—*Eucyclops (Tropocyclops) confinis* (Kiefer).

a. ♀ P 5 et segment génital (Baba Hadji) ; b. ♀ Lamelle basale de P I (Djam-Makkou) ; c. ♂ P 5 et P 6 (Baba Hadji).

Leur furca a en général été un peu plus longue, la soie dorsale (ciliée) mieux développée, la soie apicale externe de la furca a chez tous été nettement plus longue que la soie apicale interne, enfin, l'épine de P 5 a été trouvée considérablement plus longue et amincie que chez les animaux indiens, cette épine ayant chez ceux-là mesuré le plus souvent de 35 à 38  $\mu$ . Le nombre des oeufs a varié de 8 à 15 dans un ovisac.

*Habitats.*—Baba Hadji, étang eutrophique d'eau douce très claire, à 30 kilomètres au sud de Chiraz ; Bourm, mare de rivière d'eau douce dans la direction de Fal ; Djam, mares de rivière d'eau douce sur la route vers Makkou ; Tang-Qil, mares de rivière d'eau douce.

### XIII. NOTES SUR QUELQUES MEMBRES DU SOUS-GENRE *EUCYCLOPS* S. STR.

#### ***Eucyclops serrulatus* (Fischer).**

Dans ma revision des représentants indiens du groupe *serrulatus*, parue en 1939, j'avais conclu à la possibilité de l'existence d'*E. serrulatus* et d'*E. agiloides* comme deux espèces distinctes, mais j'avais fait remarquer qu' on rencontre de nombreuses formes de passage reliant les deux types extrêmes, et qu' on a parfois de grandes difficultés à décider à quelle espèce qu'il faut référer certains animaux. En effet, aucune caractéristique isolée ne m'a paru posséder à elle seule une valeur diagnostique absolue en vue de la distinction des deux formes, et c'est seulement la coexistence chez un même individu de plusieurs particularités morphologiques qui a rendu possible la séparation des deux espèces en question. Ces remarques s'appliquaient au matériel de provenance indienne que j'avais étudié.

Les faits ont été un peu différents en ce qui concerne les spécimens iraniens. De même que dans l'Inde des *Eucyclops* s. str. à longue serra sont très communs dans l'Iran et se trouvent dans un grand nombre d'habitats divers. Cependant il a été évident qu' avec une seule exception tous les animaux récoltés ont bien été des *Eucyclops serrulatus* (Fischer). Ceci aquis il faut toutefois admettre que cette espèce

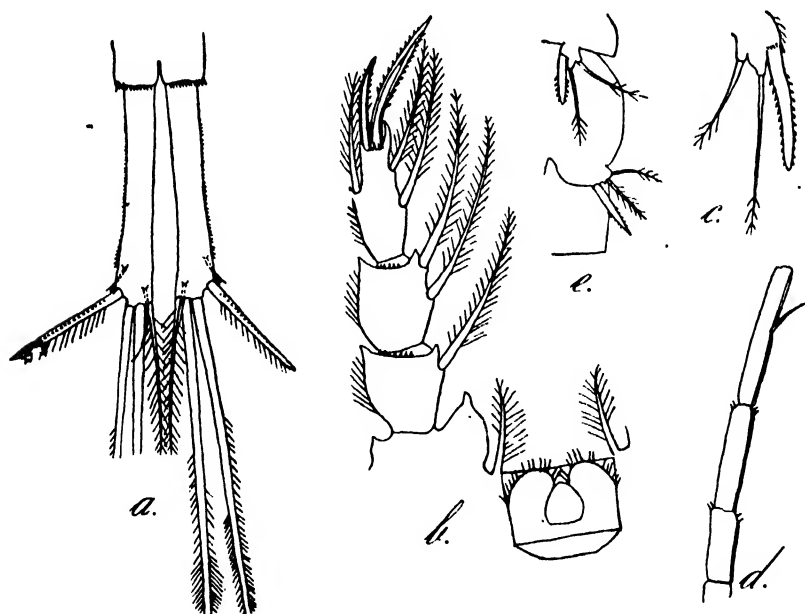


FIG. 5.—*Eucyclops serrulatus* (Fischer). ?

a. ♀ (2) Furca, face ventrale, b. ♀ (1) Lamelle basale et cnp.4 ; c. ♀ (1) P 5 ; d. ♀ (1) Première antenne, trois derniers articles ; e. ♂ P 5 et P 6.

puisse offrir des variations très considérables dans ses dimensions générales, dans la structure de la furca et de ses appendices, dans la con-

figuration de l'article terminal de l'enp. 4 et celle de la cinquième patte, pour ne faire mention que des parties les plus importantes au point de vue diagnostique.

Toutes les femelles étudiées ont été porteuses d'ovisacs. Leur longueur a varié de 864 à 1368  $\mu$  ; la plupart ont mesuré de 900 à 1100  $\mu$  (sans soies apicales). La cuticule des segments abdominaux a parfois été ornée de rangées de petites fossettes. Les branches de la furca ont le plus souvent été bien divergentes ; plusieurs des femelles de quelques localités ont cependant présenté des branches parallèles.

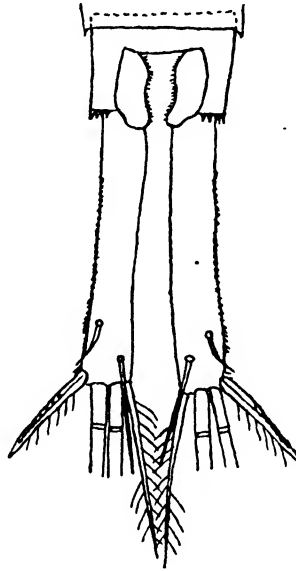


FIG. 6.—*Eucyclops serrulatus* (Fischer).

♀ Furca face dorsale (Adjanta).

Le rapport entre la longueur et la largeur est allé de 3.68 : 1 à 6.58 : 1. Le rapport de longueur entre la soie apicale interne et la soie apicale externe a varié de 1.03 : 1 à 1.59 : 1, la moyenne pour les 50 femelles étudiées a été de 1.25 : 1 (1.19 : 1 dans le cas des animaux du Sud et 1.30 : 1 chez ceux du Nord). Les mensurations de l'article 3 de l'enp. 4 et des épines apicales sont données dans le tableau et il me semble inutile de les analyser. L'article a presque toujours été inférieur en longueur à celle de l'épine apicale interne ; chez 3 individus cette épine et l'article ont été de longueur égale et chez 4 l'article a dépassé en longueur celle de l'épine apicale interne. Plusieurs animaux ont présenté des épines des pattes natatoires en forme de lancette. La base de l'épine de P 5 a, chez la grande majorité des spécimens, été plus de 3 fois aussi large que celle de la soie médiane. Le nombre des oeufs a varié de 9 à 38 dans un sac, les femelles à oeufs nombreux provenant de collections d'eau eutrophiques des provinces Caspiennes. La longueur du mâle a varié de 627 à 997  $\mu$  (sans soies apicales), la plupart

mesurant environ 800  $\mu$ . La longueur de l'épine interne de la sixième patte a chez les 19 animaux du Sud varié de 33 à 47  $\mu$  et chez ceux du Nord de 37 à 50  $\mu$ , donnant une moyenne d'environ 41  $\mu$  pour le total des 38 mâles étudiés.

*Habitats*.—Inde : Apparemment réparti dans toute l'étendue de la péninsule indienne y compris le Cachemire, tant au niveau de la mer qu'à une altitude supérieure à 4,000 mètres. Ceylan.

Iran : Sud. Abd Imam, étang oligotrophique d'eau douce ; Ahvaz, petite mare dans jardin potager municipal près de la rivière, petite mare près d'un canal d'irrigation, bassin dans jardin près du Karoun, rive gauche, étang à l'eau saumâtre près de la cimetière musulmane ; Béhbéhan, réservoir souterrain voûté, mare de rivière temporaire à l'eau saumâtre, bassin du jardin national, citerne d'eau de puits saumâtre près de l'Imam Zadéh Bachir-un-Nasir, puits à l'eau saumâtre dans les champs, bassin de l'hôpital municipal, petite rivière temporaire ; Bender Chahpour, mare à l'eau saumâtre, citerne d'eau douce ; Bourm, source d'eau douce, mare de rivière entre Bourm et Fal ; Chouch (Suse), fosse près de la gare, citerne près de la gare, marécage près du village ; Chouchter, mares dans le lit de la rivière Minaou ; rivière Minaou ; Djam, mares de rivière entre Djam et Makkou ; Djavakan, mare près d'un canal ; Firouzabad, bassin ; Gatch Saran, mare près d'un torrent d'eau douce ; Khorramchahr, fosses, ruisseau (1935) ; Mansouriyéh, mare à surface couverte d'algues vertes ; Marghazar, fosse près de la gare ; Tang-Gaz, mares de rivière à l'eau saumâtre, environ 6 km. d'Ahmédabad ; Tang-Qil, mares de rivière à l'eau douce.

Provinces Caspiennes. Chahi, mare du fleuve Talar, fosse, rizière, autre fosse, fosse près du fleuve Talar, mare eutrophique près d'un ruisseau ; Gorgan, mare sans végétation, bassin, autre mare sans végétation, autre mare ; Lahidjan, rizière, marais, fosses ; Langueroud, mare ; Pahlévi, rivière, lagune (2 échantillons) ; Ramsar, mare près d'un torrent, petit étang, marais, mare, autre mare ; Reclt, ruisseau ; Sari, mare, bassin, fosse d'excavation près de la voie ferrée, rizière.

Plateau et Est. Broudjerd, étang (1935) ; Chahroud, bassin d'un caravansérail, mare à fond de feuilles décomposées, mare près d'un canal d'irrigation, bassin de la Banque Mellie ; Chiraz, bassin d'un jardin, puits (1935) ; Isfahan, petit étang près d'un ruisseau, étang (1935) ; Keredj, mare à feuilles décomposées, petite mare eutrophique, mare de rivière à l'eau remplie d'algues, autre mare de rivière semblable, mare à végétation émergente ; Méchhed, bassin (1935) ; Pasghaléh, chute d'eau dans de la mousse ; Qoum, rivière à l'eau saumâtre (1935) ; Robat-Khan, étang salin (1935).

Comme il a déjà été mentionné l'*E. serrulatus* se rencontre dans les biotopes les plus divers. On le voit aussi bien dans des étangs à végétation abondante que dans de petites mares d'eau de pluie et des bassins oligotrophiques. Il n'est pas rare dans l'eau souterraine des puits et se laisse pêcher assez fréquemment dans l'eau courante des rivières, et il tolère une grande variation de température et de salinité. Je donne ci-dessous un tableau récapitulatif des habitats dans lesquels

je l'ai récolté au cours de mes voyages en automne 1935 et pendant l'hiver 1939-40.

Mares à l'eau douce	..	..	..	..	..	..	..	17
Mares à l'eau saumâtre	..	..	..	..	..	..	..	3
Bassins	..	..	..	..	..	..	..	10
Mares de rivières à l'eau douce	..	..	..	..	..	..	..	7
Mares de rivières à l'eau saumâtre	..	..	..	..	..	..	..	2
Fosses à l'eau douce	..	..	..	..	..	..	..	7
Fosse à l'eau saumâtre	..	..	..	..	..	..	..	1
Etangs d'eau douce	..	..	..	..	..	..	..	4
Etangs d'eau saumâtre	..	..	..	..	..	..	..	3
Rivières et ruisseaux d'eau douce	..	..	..	..	..	..	..	4
Rivières d'eau saumâtre	..	..	..	..	..	..	..	2
Rizières	..	..	..	..	..	..	..	3
Marécages à l'eau douce	..	..	..	..	..	..	..	3
Citernes d'eau douce	..	..	..	..	..	..	..	2
Citerne d'eau saumâtre	..	..	..	..	..	..	..	1
Réservoir souterrain d'eau douce	..	..	..	..	..	..	..	1
Puits à l'eau douce	..	..	..	..	..	..	..	1
Puits à l'eau saumâtre	..	..	..	..	..	..	..	1
Source d'eau douce	..	..	..	..	..	..	..	1
Lagune	..	..	..	..	..	..	..	2
Chute d'eau dans de la mousse	..	..	..	..	..	..	..	1

### **Eucyclops agiloides (Sars).**

J'ai déjà mentionné, que tandis que des formes offrant les caractéristiques d'*E. serrulatus* sont très répandues dans toute l'Empire, je n'ai récolté des animaux répondant à la description d'*E. agiloides* que dans une seule localité (dans le Roud Ambar Safed, tributaire du fleuve Mand).

Une épine peu élargie de la cinquième patte chez la femelle et une épine ventrale relativement courte de la sixième patte du mâle semblent constituer deux traits essentiels de cette espèce dont la signification reste toujours douteuse, les formes de passage étant nombreuses et semblant la relier insensiblement à l'*E. serrulatus*. Des mensurations sont données de quelques animaux sans qu'il ne me soit possible à présent d'entrer plus en avant dans ce sujet. Les femelles examinées avaient les branches de la furca parallèles.

*Habitats.*—Inde : Semble se rencontrer dans toute l'étendue de la péninsule indienne.

Iran : Tchamelki, rivière à l'eau saumâtre (région située entre Djam et Firouzabad).



**Eucyclops speratus** (Lilljeborg).

Dans la revision déjà mentionnée des espèces connues de l'Inde du sous-genre *Eucyclops* s. str. j'avais cru devoir référer à l'espèce *E. speratus* des spécimens récoltés d'une petite mare aux grottes d'Adjanta. A cette époque je n'avais pas été à même d'examiner des *E. speratus* d'Europe et je ne connaissais cette forme que d'après les descriptions de Lilljeborg, Sars et Kiefer. Dernièrement, grâce à la grande obligeance du Professeur Sixten Bock de Stockholm, j'ai pu examiner deux femelles d'*E. speratus* provenant du lac Maelaren en Suède. Cet examen m'a montré que les animaux d'Adjanta en diffèrent trop pour pouvoir être identifiés avec *E. speratus* et qu'ils se rapprochent davantage d'*E. errulatus* et doivent, je crois, être considérés comme une forme à furca très longue de cette espèce.

Dans un bassin de l'hôtel des "Quatres jardins" à Isfahan j'ai récolté deux femelles et trois mâles qui ont offert certaines ressemblances tant avec *E. speratus* qu'avec les animaux d'Adjanta, sans qu'il ait

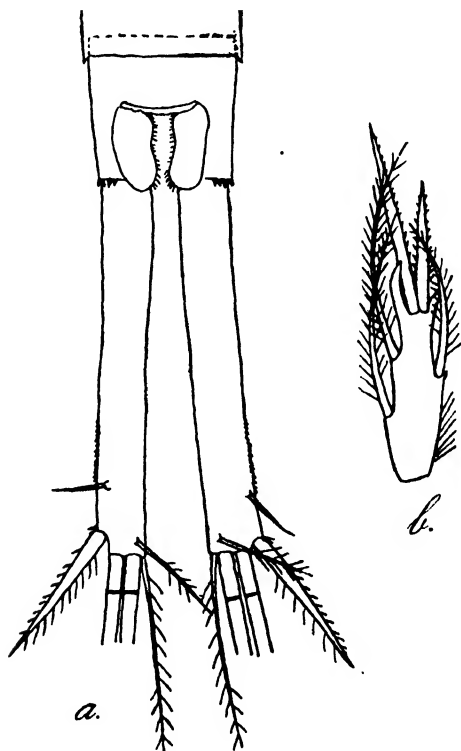


FIG. 7.—*Eucyclops speratus* (Lilljeborg).

a. ♀ Furca, face dorsale ; b. ♀ Article 3 enp. 4.

été possible de les identifier ni avec l'un ni avec les autres. Par suite de l'état actuel très imparfait de nos connaissances sur *E. serrulatus*

et son amplitude de variations il ne me semble pas justifié de décrire les animaux d'Isfahan comme représentant une forme nouvelle et je me borne à les présenter ici sous le nom d'*E. serrulatus* ? et d'en donner quelques mensurations et des figures. J'ajoute aussi un dessin montrant la furca et l'article terminal de l'enp. 4 d'un des spécimens du lac Maclaren et celui de la furca d'une femelle d'Adjanta. En ce qui concerne les mensurations des animaux de cette dernière localité il faudrait se rapporter au tableau p. 397 de la revision déjà citée. La première antenne atteignait rabattue respectivement le tiers antérieur et le bord postérieur du deuxième segment thoracique chez les deux *E. speratus*, le tiers antérieur et le milieu du deuxième segment thoracique chez les deux femelles d'Isfahan, et le bord postérieur du deuxième segment thoracique chez la plupart des individus d'Adjanta. L'échancrure anale était pourvue de petits poils chez les *E. speratus* et de longs poils chez les animaux d'Isfahan et d'Adjanta. Pour autant que je le sache *E. speratus* Lilljeborg n'a encore jamais été rencontré ni dans l'Inde ni dans l'Iran.

### **Eucyclops euacanthus** (Sars).

Je n'ai rencontré des spécimens réferables à cette espèce que dans deux localités. Dans l'étang d'eau douce à Baba Hadji il s'est trouvé parmi de nombreux *E. farsicus* Lindberg une femelle unique qui répondait bien à la description d'*E. euacanthus* par Sars et par Kiefer, tout en possédant une première antenne plus longue. Elle avait une furca à branches divergentes, écartées à la base, à soie apicale interne glabre et courbée, légèrement inférieure en longueur à celle de la branche de la furca. La serra était complète, composée d'environ 34 spinules peu serrées, les dernières un peu plus longues que les autres. L'échancrure anale, très béante, semblait dépourvue de poils. La première antenne atteignait, lorsqu'elle était rabattue, le tiers postérieur du deuxième segment céphalothoracique. Les trois derniers articles portaient une membrane hyaline découpée en petites spinules très distinctes. Les épines des pattes natatoires offraient l'aspect typique en lancette. L'épine interne de P 5 était assez courte (30  $\mu$ ) et bien moins de deux fois aussi large que la soie médiane de cette patte. Dans une rivière à l'eau saumâtre à Khorab (au sud de Firouzabad) j'ai récolté trois mâles qui semblaient aussi appartenir à cette même espèce. La soie apicale interne de la furca était courbée et manquait de cils également chez eux, et je n'ai pas pu voir des poils au niveau de l'échancrure anale. Les épines des pattes natatoires présentaient la structure lancéolée. L'épine de P 6 était considérablement plus courte que le deuxième segment abdominal.

### **Eucyclops macruroides** (Lilljeborg).

Dans un étang eutrophique à l'eau douce à Chahi j'ai trouvé quelques individus répondant bien aux caractéristiques d'*E. macruroides*,

tel qu'il a été décrit par Lilljeborg. J'en donne quelques mensurations et des figures.

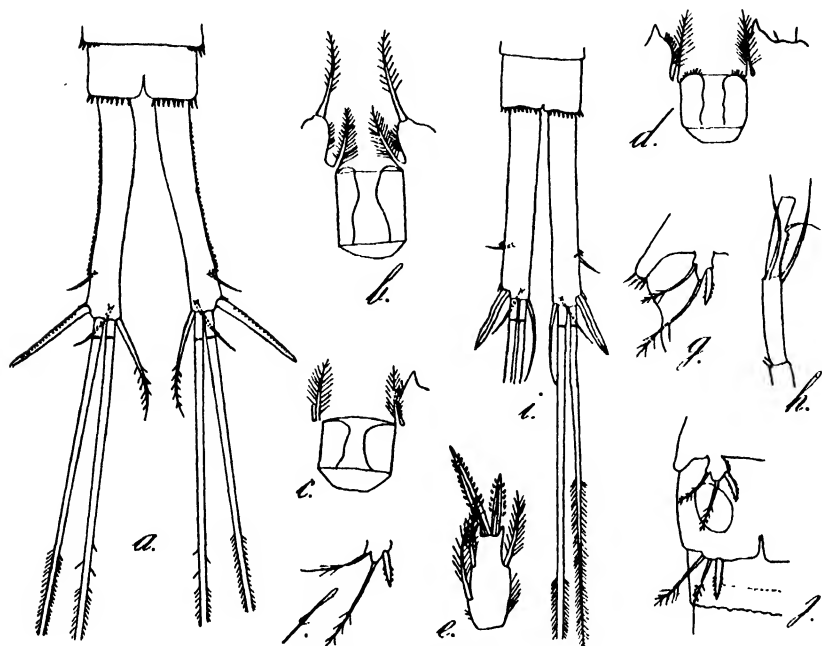


FIG. 8.—*Eucyclops macruiroides* (Lilljeborg).

a. ♀ (1) Furca, face ventrale ; b. ♀ (2) Lamelle basale de P 1 ; c. ♀ (1) Lamelle basale de P 4 ; d. ♀ (2) Lamelle basale de P 4 ; e. ♀ (1) Article 3 emp. 4 ; f. ♀ (1) P 5 ; g. ♀ (2) P 5 ; h. ♀ (2) Première antenne, deux derniers articles ; i. ♂ Furca, face ventrale ; j. ♂ P 5 et P 6.

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*Cyclops (Microcyclops) varicans* Sars ♀.

Localité.	Longueur. μ	Furca. Long. : larg.	Sole dors.	Soie ap. int. : -sole ap. ext.	Enp. 4. Art. 2. Long. : larg.	Enp. 4. Art. 2. Enp. ap. int. : ép ap. ext.	Enp. 4. Long. art. 2 : ép. ap. int.	P. 6 Epure : sole med. : sole ext.
<i>Chahi</i> Mare.	788	(45+20) : 22=2-93 : 1	67	X : 50= X : 1	73 : 29=2-32 : 1	62 : 35=1-77 : 1	1-18 : 1	..
	784	(50+20) : 20=3-50 : 1	67	85 : 58=1-46 : 1	..	..	..	..
	741	(47-20) : 19=3-53 : 1	52	77 : 50=1-54 : 1	69 : 30=2-30 : 1	41 : 27=1-52 : 1	1-68 : 1	..
	769	(50+23) : 22=3-32 : 1	53	83 : 52=1-59 : 1	77 : 32=2-40 : 1	55 : 28=1-96 : 1	1-40 : 1	..
<i>Gorgan</i> Mare.	908	(53+20) : 23=3-26 : 1	62	93 : 60=1-55 : 1	82 : 32=2-56 : 1	59 : 37=1-59 : 1	1-39 : 1	..
	988	(44-23) : 22=3-04 : 1	60	103 : 58=1-78 : 1	83 : 36=2-30 : 1	55 : 37=1-49 : 1	1-50 : 1	..
	831	(60+25) : 23=3-60 : 1	52	83 : 58=1-43 : 1	83 : 35=2-37 : 1	50 : 33=1-52 : 1	1-66 : 1	..
<i>Lalidjan</i> Etang.	940	(46+22) : 20=3-40 : 1	57	X : 53= X : 1	85 : 33=2-57 : 1	50 : 28=1-78 : 1	1-70 : 1	..
	769	(48+22) : 18=3-80 : 1	58	75 : 55=1-36 : 1	78 : 32=2-33 : 1	53 : 35=1-57 : 1	1-42 : 1	..
	817	(44+24) : 20=3-40 : 1	67	75 : 53=1-42 : 1	75 : 32=2-34 : 1	53 : 32=1-81 : 1	1-29 : 1	..
	893	73 : 23=3-17 : 1	..	..	75 : 33=2-27 : 1	52 : 32=1-62 : 1	1-44 : 1	..
	826	73 : 21=3-48 : 1	..	..	67 : 27=2-48 : 1	50 : 28=1-78 : 1	1-34 : 1	..
	826	(51-22) : 22=3-32 : 1	..	83 : 57=1-49 : 1	73 : 30=2-43 : 1	52 : 32=1-62 : 1	1-40 : 1	..
<i>Ramsar</i> Petit étang.	921	(60+23) : 22=3-77 : 1	62	102 : 53=1-92 : 1	82 : 32=2-56 : 1	48 : 32=1-50 : 1	1-70 : 1	..
<i>Rechi</i> Ruisscau.	807	(55+20) : 20=3-75 : 1	58	X : 58= X : 1	75 : 30=2-50 : 1	50 : 30=1-67 : 1	1-50 : 1	..
	883	(27+25) : 22=2-36 : 1	60	88 : 67=1-31 : 1	91 : 37=2-46 : 1	50 : 33=1-52 : 1	1-82 : 1	..
<i>Sari</i> Rizièr.	855	(54+23) : 22=3-50 : 1	62	87 : 58=1-50 : 1	85 : 33=2-57 : 1	58 : 40=1-45 : 1	1-46 : 1	..
<i>Chouch (Suar) gare</i> Clèrme.	921	(53+22) : 20=3-75 : 1	50	77 : 53=1-45 : 1	92 : 32=2-56 : 1	46 : 28=1-64 : 1	1-73 : 1	..
<i>Chouch (Suar) village</i> Maréage.	860	(48+22) : 21=3-33 : 1	63	93 : 63=1-48 : 1	85 : 30=2-83 : 1	61 : 37=1-65 : 1	1-39 : 1	..
	883	(47-20) : 22=3-04 : 1	53	83 : 53=1-55 : 1	77 : 30=2-57 : 1	52 : 33=1-58 : 1	1-48 : 1	..

*Cyclops (Microcyclops) varicans* Sars ♀—contd.

Localité.	Longueur. μ	Furva. Long : larg.	Soie dors.	Soie ap. int. : sole ap. ext.	Exp. 4. Art. 2. Long. : larg.	Exp. 4. Art. 2. Ep. ap. int. : ep. ap. ext.	Exp. 4. Long. art. 2 : ep. ap. int.	P 6 Epine : soie med. : soie ext
<i>Dihak</i> Source.	708	(57 ÷ 25) : 20 = 4.10 : 1	60	83 : 53 = 1.57 : 1	72 : 28 = 2.57 : 1	53 : 28 = 1.89 : 1	1.36 : 1	..
<i>Tang-Qil</i> Mare de rivière.	841	(58 ÷ 27) : 20 = 4.25 : 1	83	97 : 59 = 1.64 : 1	73 : 30 = 2.43 : 1	59 : 32 = 1.84 : 1	1.24 : 1	..

*Cyclops (Microcyclops) varicans* Sars ♂.

Localité.	Longueur. μ	Furva. Long : larg.	Soie dors.	Soie ap. int. : sole ap. ext.	Exp. 4. Art. 2. Long. : larg.	Exp. 4. Art. 2. Ep. ap. int. : ep. ap. ext.	Exp. 4. Long. art. 2 : ep. ap. int.	P 6 Epine : soie med. : soie ext
<i>Chaki</i> Riziére.	598	....	..	...	50 : 20 = 2.50 : 1	33 : 17 = 1.94 : 1	1.52 : 1	16 : 10 : 23
<i>Goryon</i> Mare.	651	(25 ÷ 17) : 18 = 2.33 : 1	42	77 : 42 = 1.83 : 1	55 : 24 = 2.29 : 1	41 : 22 = 1.86 : 1	1.34 : 1	16 : X : 25
<i>Lakidjon</i> Etang.	608	(31 ÷ 15) : 17 = 2.70 : 1	45	70 : 43 = 1.63 : 1	42 : 18 = 2.33 : 1	37 : 19 = 1.95 : 1	1.13 : 1	10 : X : 23
<i>Chouch (Suer)</i> village Maréage.	693	(30 ÷ 18) : 17 = 2.82 : 1	43	72 : 45 = 1.60 : 1	53 : 23 = 2.30 : 1	37 : 21 = 1.76 : 1	1.43 : 1	15 : 20 : 35

*Cyclops (Microcyclops) linjanticus* Kiefer.

Localité.	Longueur. μ	Furva. Long : larg.	Soie dors.	Soie ap. int. : sole ap. ext.	Exp. 4. Art. 2. Long. : larg.	Exp. 4. Art. 2. Ep. ap. int. : ep. ap. ext.	Exp. 4. Long. art. 2 : ep. ap. int.	P 6 Epine : soie med. : soie ext
<i>Lakidjon</i> ;	≤ 655	(45 ÷ 18) : 17 = 3.70 : 1	..	72 : 33 = 2.18 : 1	..	..	..	..
<i>Palitieri-Ghazian</i>	≤ 651	(51 ÷ 17) : 18 = 3.78 : 1	..	87 : 37 = 2.35 : 1	44 : 20 = 2.20 : 1	35 : 9 = 3.81 : 1	1.26 : 1	..
	♂ 532	(29 ÷ 13) : 16 = 2.62 : 1	..	102 : 37 = 2.76 : 1	42 : 16 = 2.62 : 1	40 : 7.5 = 5.33 : 1	1.05 : 1	16 : 10 : 28
<i>Recht</i>	≤ 680	(52 ÷ 18) : 19 = 3.63 : 1	33	83 : 37 = 2.24 : 1	48 : 20 = 2.40 : 1	38 : 9 = 4.22 : 1	1.26 : 1	..
<i>Dihak</i>	≤ 646	(42 ÷ 15) : 18 = 3.16 : 1	..	87 : 42 = 2.07 : 1	47 : 17 = 2.76 : 1	33 : 10 = 3.30 : 1	1.42 : 1	..
<i>Rèkér</i>	≤ 627	(33 ÷ 15) : 18 = 3.67 : 1	..	80 : 40 = 2 : 1	42 : 16 = 2.62 : 1	30 : 10 = 3 : 1	1.40 : 1	..
	≤ 693	(43 ÷ 17) : 18 = 3.33 : 1	..	95 : 45 = 2.11 : 1	47 : 17 = 2.76 : 1	35 : 9 = 3.81 : 1	1.34 : 1	..
	≤ 613	(42 ÷ 15) : 17 = 3.35 : 1	33	92 : 42 = 2.19 : 1	44 : 18 = 2.44 : 1	29 : 8 = 3.62 : 1	1.52 : 1	..
<i>Djam-Makhou</i>	≤ 610	(39 ÷ 18) : 18 = 3.17 : 1	42	88 : 39 = 2.26 : 1	43 : 15 = 2.87 : 1	33 : 11 = 3 : 1	1.30 : 1	..

*Eucyclops (Tropocyclops) prasinus* (Fischer).

Localité.	Longueur. μ	Furca. Long. : larg.	Sole dors.	Sole ap. mcd. int. : furca.	Soie ap. ext. : soie ap. int.	Enp. 4. Art. 3. Long. : larg.	Enp. 4. Art. 3. Ep. ap. int. : ép. ap. ext.	Enp. 4. Ep. ap. int. : long. art. 3.	P 6 Epine.	Formule des épinés.
Mansourkèch	♀ 852	(27+23) : = 2.50 : 1	58	302 : 30 = 6 : 1	46 : 45 = 1.02 : 1	47 : 18 = 2.61 : 1 (droite) 50 : 22 = 2.27 : 1 (gauche)	73 : 37 = 2.03 : 1 (droite)	1.59 : 1 (droite)	..	$\begin{cases} 3+4+3 \\ 3+3+3 \end{cases}$

*Eucyclops (Tropocyclops) confinis* Kiefer.

Djam-Makou	♀ 646	(25+16) : 16 = 2.56 : 1	47	267 : 41 = 6.51 : 1	38 : 31 = 1.23 : 1	29 : 13 = 2.23 : 1	72 : 35 = 2.06 : 1	2.48 : 1	..	3+4-3-3
	♀ 703	(25+16) : 16 = 2.56 : 1	47	264 : 41 = 6.44 : 1	40 : 30 = 1.33 : 1	..	..	..	..	3+4-3-3
	♀ 710	(25+18) : 17 = 2.53 : 1	50	259 : 43 = 6.02 : 1	42 : 32 = 1.31 : 1	28 : 14 = 2 : 1	75 : 38 = 1.97 : 1	2.08 : 1	..	3+4-3-3
	♂ 503	(15+12) : 15 = 1.80 : 1	35	175 : 27 = 6.48 : 1	25 : 19 = 1.32 : 1	26 : 11 = 2.36 : 1	50 : 33 = 1.79 : 1	2.27 : 1	17	3+4-3-3
Baba Hadji	♀ 646	(26+15) : 15 = 2.73 : 1	53	230 : 41 = 5.61 : 1	37 : 30 = 1.23 : 1	31 : 12 = 2.58 : 1	75 : 35 = 2.14 : 1	2.42 : 1	..	3+4-3-3
	♀ 632	(25+15) : 16 = 2.50 : 1	50	200 : 40 = 5 : 1	37 : 33 = 1.12 : 1	31 : 14 = 2.21 : 1	80 : 38 = 2.10 : 1	2.58 : 1	..	3+4-3-3
	♀ 627	(24+16) : 15 = 2.66 : 1	50	225 : 40 = 5.62 : 1	37 : 31 = 1.19 : 1	32 : 13 = 2.46 : 1	78 : 36 = 2.17 : 1	2.33 : 1	..	3+4-3-3
	♀ 617	(24+16) : 16 = 2.50 : 1	55	200 : 40 = 5 : 1	37 : 31 = 1.19 : 1	32 : 13 = 2.46 : 1	78 : 35 = 2.23 : 1	2.33 : 1	..	3+4-3-3
	♂ 503	(17+15) : 13 = 2.46 : 1	38	184 : 32 = 5.75 : 1	27 : 20 = 1.35 : 1	28 : 11 = 2.54 : 1	65 : 33 = 1.97 : 1	2.32 : 1	15	3+4-3-3
Tang-Qil	♀ 603	(29+16) : 18 = 2.50 : 1	43	225 : 43 = 5 : 1	42 : 33 = 1.27 : 1	30 : 14 = 2.14 : 1	75 : 37 = 2.03 : 1	2.50 : 1	..	3+4-3-3
	♀ 656	(25+16) : 17 = 2.41 : 1	42	247 : 41 = 6.02 : 1	38 : 30 = 1.27 : 1	28 : 12 = 2.33 : 1	72 : 37 = 1.95 : 1	2.57 : 1	..	3+4-3-3
Bourm	♀ 655	(26+15) : 17 = 2.41 : 1	48	247 : 41 = 6.02 : 1	38 : 33 = 1.15 : 1	29 : 14 = 2.07 : 1	75 : 35 = 2.14 : 1	2.58 : 1	..	3+4-3-3

*Eucyclops serrulatus* (Fischer) ♀.

Localité.	Longueur. μ	Furca. Long. : larg.	Furca. Sole ap. int. : sole ap. ext.	Enp. 4. Art. term. Long. : larg.	Enp. 4. Ep. ap. int. : ép. ap. ext.	Enp. 4. Art. term. : ép. ap. int.	Chaque patte Epine : sole méd. (larg. approx.).
<i>Ahraz</i>	1064	130 : 26 = 5 : 1	87 : 78 = 1 : 12 : 1	67 : 27 = 2 : 48 : 1	83 : 57 = 1 : 46 : 1	0-80 : 1	3-2 : 1
Petite mare	1226	148 : 24 = 6 : 17 : 1	100 : 73 = 1 : 37 : 1	67 : 27 = 2 : 48 : 1	75 : 52 = 1 : 44 : 1	0-89 : 1	3-1 : 1
Autre petite mare	1045	130 : 27 = 4 : 81 : 1	88 : 75 = 1 : 17 : 1	63 : 32 = 1 : 96 : 1	75 : 57 = 1 : 33 : 1	0-84 : 1	3-1 : 1
Bassin	1045	117 : 25 = 4 : 68 : 1	83 : 67 = 1 : 24 : 1	60 : 23 = 2 : 60 : 1	58 : 48 = 1 : 20 : 1	1-03 : 1	3-1 : 1
<i>Elbédhan</i>	1053	133 : 27 = 4 : 93 : 1	92 : 72 = 1 : 28 : 1	63 : 26 = 2 : 42 : 1	77 : 53 = 1 : 45 : 1	0-82 : 1	3-1 : 1
Réservoir souterrain	1055	125 : 26 = 4 : 80 : 1	80 : 70 = 1 : 14 : 1	65 : 28 = 2 : 32 : 1	73 : 55 = 1 : 33 : 1	0-89 : 1	3-1 : 1
Petite rivière à l'eau saumâtre	1083	132 : 27 = 4 : 89 : 1	87 : 83 = 1 : 05 : 1	72 : 27 = 2 : 67 : 1	75 : 58 = 1 : 29 : 1	0-96 : 1	3-1 : 1
Bassin	1007	117 : 25 = 4 : 68 : 1	83 : 72 = 1 : 15 : 1	60 : 28 = 2 : 14 : 1	70 : 52 = 1 : 35 : 1	0-86 : 1	3-1 : 1
Mare de rivière temporaire							
<i>Bender Chakpour</i>	1092	138 : 23 = 6 : 1	85 : 80 = 1 : 06 : 1	63 : 27 = 2 : 33 : 1	78 : 58 = 1 : 34 : 1	0-80 : 1	3-1 : 1
Citerne d'eau douce	1054	123 : 23 = 5 : 35 : 1	87 : 75 = 1 : 16 : 1	62 : 27 = 2 : 29 : 1	75 : 52 = 1 : 44 : 1	0-83 : 1	3-1 : 1
Mare à l'eau saumâtre							
<i>Bourm</i>	903	108 : 25 = 4 : 32 : 1	78 : 63 = 1 : 14 : 1	58 : 23 = 2 : 07 : 1	67 : 50 = 1 : 34 : 1	0-81 : 1	3-4 : 1
Source	940	117 : 23 = 5 : 09 : 1	88 : 73 = 1 : 20 : 1	57 : 26 = 2 : 10 : 1	73 : 50 = 1 : 50 : 1	0-76 : 1	3-1 : 1
Mare de rivière entre Bourm et Fal.							
<i>Chouch (Suse)</i>	1102	140 : 27 = 5 : 18 : 1	88 : 83 = 1 : 06 : 1	67 : 27 = 2 : 48 : 1	75 : 50 = 1 : 50 : 1	0-89 : 1	3-1 : 1
Fosse près de la gare							
<i>Chouchier</i>	940	103 : 22 = 4 : 65 : 1	92 : 63 = 1 : 46 : 1	58 : 25 = 2 : 32 : 1	60 : 43 = 1 : 39 : 1	0-97 : 1	3-1 : 1
Rivière Minaou	1045	126 : 26 = 4 : 8 : 1	85 : 60 = 1 : 42 : 1	62 : 25 = 2 : 48 : 1	63 : 48 = 1 : 31 : 1	0-98 : 1	3-1 : 1
Mare dans le lit d'une petite rivière							
<i>Djam</i>	1007	98 : 23 = 4 : 26 : 1	78 : 58 = 1 : 34 : 1	60 : 25 = 2 : 40 : 1	67 : 46 = 1 : 46 : 1	0-89 : 1	3-1 : 1
Rivière entre Djam et Makkou	959	118 : 23 = 5 : 13 : 1	83 : 52 = 1 : 59 : 1	60 : 25 = 2 : 40 : 1	67 : 48 = 1 : 39 : 1	0-89 : 1	2-5 : 1
	998	122 : 25 = 4 : 88 : 1	93 : 75 = 1 : 22 : 1	58 : 28 = 2 : 07 : 1	77 : 53 = 1 : 45 : 1	0-75 : 1	3-3 : 1

<i>Djaccan</i> Mare près d'un canal	1045	125 : 23 = 5.43 : 1	85 : 67 = 1.27 : 1	63 : 28 = 2.25 : 1	70 : 50 = 1.40 : 1	0.80 : 1	3.1 : 1
<i>Firouzabad</i> Bassin	1016	115 : 25 = 4.6 : 1	75 : 52 = 1.44 : 1	67 : 27 = 2.48 : 1	75 : 53 = 1.42 : 1	0.89 : 1	3.6 : 1
<i>Khorranchahr</i> Fosse	1150	158 : 30 = 5.27 : 1	100 : 97 = 1.03 : 1	72 : 32 = 2.25 : 1	83 : 67 = 1.24 : 1	0.84 : 1	3.1 : 1
Marcéage	997	133 : 26 = 5.12 : 1	83 : 80 = 1.04 : 1	63 : 27 = 2.33 : 1	72 : 50 = 1.44 : 1	0.87 : 1	3.1 : 1
<i>Manouriyth</i>	988	125 : 27 = 4.63 : 1	75 : 68 = 1.10 : 1	53 : 29 = 1.83 : 1	68 : 50 = 1.36 : 1	0.78 : 1	3.4 : 1
Mare							
<i>Tang-Gaz</i>	908	92 : 25 = 3.68 : 1	87 : 83 = 1.05 : 1	57 : 25 = 2.28 : 1	67 : 50 = 1.34 : 1	0.85 : 1	3.1 : 1
Rivière	941	93 : 25 = 3.72 : 1	90 : 77 = 1.17 : 1	52 : 25 = 2.08 : 1	67 : 45 = 1.49 : 1	0.77 : 1	2.4 : 1
<i>Chahi</i> Mare du fleuve Talar	988	132 : 26 = 5.06 : 1	73 : 67 = 1.16 : 1	63 : 27 = 2.33 : 1	84 : 65 = 1.29 : 1	0.75 : 1	3.3 : 1
Mare eutrophi que près d'un ruisseau	988	123 : 25 = 4.92 : 1	80 : 70 = 1.14 : 1	65 : 27 = 2.40 : 1	70 : 52 = 1.35 : 1	0.93 : 1	3.6 : 1
Fosse	1225	158 : 24 = 6.58 : 1	87 : 68 = 1.28 : 1	65 : 30 = 2.17 : 1	75 : 56 = 1.34 : 1	0.87 : 1	3.1 : 1
<i>Chahroud</i> Bassin	1368	150 : 31 = 4.84 : 1	103 : 68 = 1.51 : 1	77 : 28 = 2.75 : 1	80 : 57 = 1.40 : 1	0.96 : 1	4.1 : 1
Autre bassin	1140	135 : 27 = 5 : 1	100 : 75 = 1.39 : 1	77 : 28 = 2.75 : 1	75 : 55 = 1.36 : 1	1.03 : 1	3.6 : 1
Marcéage près d'un canal	1159	147 : 27 = 5.44 : 1	100 : 68 = 1.47 : 1	70 : 27 = 2.59 : 1	78 : 57 = 1.37 : 1	0.89 : 1	4.1 : 1
Petite mare à feuilles décomposées	1045	113 : 25 = 4.52 : 1	88 : 70 = 1.26 : 1	58 : 28 = 2.07 : 1	53 : 43 = 1.35 : 1	1 : 1	3.1 : 1
<i>Deband</i> Mare de torrent	1088	125 : 27 = 4.63 : 1	100 : 67 = 1.49 : 1	67 : 25 = 2.68 : 1	70 : 50 = 1.40 : 1	0.96 : 1	3.1 : 1
<i>Goran</i> Mare sans végétation	1273	158 : 29 = 5.45 : 1	97 : 87 = 1.11 : 1	65 : 30 = 2.17 : 1	87 : 57 = 1.53 : 1	0.75 : 1	3.1 : 1
Autre mare sans végétation	1273	147 : 25 = 5.88 : 1	90 : 77 = 1.17 : 1	67 : 31 = 2.16 : 1	75 : 58 = 1.29 : 1	0.89 : 1	3.1 : 1
Bassin	1254	167 : 29 = 5.76 : 1	93 : 70 = 1.33 : 1	77 : 32 = 2.40 : 1	88 : 63 = 1.39 : 1	0.87 : 1	3.1 : 1
Petite mare	1102	142 : 25 = 5.68 : 1	103 : 83 = 1.24 : 1	70 : 30 = 2.33 : 1	83 : 58 = 1.43 : 1	0.84 : 1	3.6 : 1
<i>Kerdi</i> Mare à feuilles décomposées	1188	158 : 28 = 5.64 : 1	117 : 77 = 1.52 : 1	80 : 27 = 2.96 : 1	75 : 53 = 1.42 : 1	1.07 : 1	4.1 : 1
Petite mare eutrophi que	1169	120 : 25 = 4.80 : 1	103 : 75 = 1.37 : 1	73 : 25 = 2.92 : 1	72 : 52 = 1.38 : 1	1.01 : 1	3.1 : 1



*Eucyclops serrulatus* (Fischer) ♀—contd.

Localité.	Longueur. μ	Furca Long. : larg.	Furca Sole ap. int. : sole ap. ext.	Exp. 4. Art. term. Long. : larg.	Exp. 4. Ep. ap. int. : ép. ap. ext.	Exp. 4. Art. term. : ép. ap. int.	Cinquième patte Epine : sole méd. (larg. approx.).
Mare à végétation émergente	864	103 : 23 = 4.68	83 : 62 = 1.34 : 1	58 : 25 = 2.32 : 1	65 : 52 = 1.25 : 1	0.89 : 1	3.1 : 1
Mare de rivière	1045	133 : 27 = 4.93 : 1	100 : 65 = 1.54 : 1	73 : 25 = 2.92 : 1	73 : 50 = 1.46 : 1	1 : 1	4.1 : 1
<i>Paklari</i>	1045	125 : 25 = 5 : 1	98 : 70 = 1.40 : 1	60 : 27 = 2.22 : 1	68 : 50 = 1.36 : 1	0.88 : 1	3.1 : 1
Lagune	997	127 : 25 = 5.08 : 1	83 : 67 = 1.24 : 1	62 : 27 = 2.29 : 1	75 : 58 = 1.29 : 1	0.83 : 1	3.1 : 1
Rivière	940	113 : 23 = 4.91 : 1	83 : 67 = 1.24 : 1	58 : 27 = 2.15 : 1	72 : 52 = 1.38 : 1	0.80 : 1	2 : 1
<i>Ransar</i>							
Mare	997	103 : 25 = 4.01 : 1	83 : 63 = 1.32 : 1	58 : 25 = 2.32 : 1	58 : 43 = 1.35 : 1	1 : 1	2.5 : 1
Marais	950	117 : 25 = 4.68 : 1	83 : 58 = 1.43 : 1	57 : 30 = 1.90 : 1	67 : 47 = 1.43 : 1	0.85 : 1	3.1 : 1
Mare près d'un torrent	997	123 : 23 = 5.35 : 1	90 : 77 = 1.17 : 1	63 : 28 = 2.25 : 1	67 : 52 = 1.29 : 1	0.94 : 1	3.1 : 1
<i>Rechi</i>							
Ruisseau	1045	137 : 26 = 5.27 : 1	92 : 70 = 1.31 : 1	63 : 30 = 2.10 : 1	72 : 52 = 1.38 : 1	0.87 : 1	3.1 : 1
<i>Sari</i>							
Fosse près de la voie ferrée	1035	130 : 23 = 5.65 : 1	70 : 65 = 1.08 : 1	63 : 30 = 2.10 : 1	92 : 65 = 1.42 : 1	0.68 : 1	3.1 : 1
Rizière	1065	147 : 25 = 5.25 : 1	93 : 75 = 1.22 : 1	72 : 32 = 2.25 : 1	88 : 63 = 1.39 : 1	0.82 : 1	3.1 : 1

*Eucyclops serrulatus* (Fischer) ♂.

Localité.	Longueur. μ	Furca Long. : larg.	Furca Sole ap. int. : sole ap. ext.	Exp. 4. Art. term. Long. : larg.	Exp. 4. Ep. ap. int. : ép. ap. ext.	Exp. 4. Art. term. : ép. ap. int.	Sixième patte Epine : sole méd. : sole ext.
<i>Ahaz</i>							
Basin	788	82 : 18 = 4.55 : 1	67 : 40 = 1.67 : 1	45 : 16 = 2.81 : 1	53 : 35 = 1.51 : 1	0.85 : 1	42 : 33 : 37
Étang	855	87 : 18 = 4.83 : 1	53 : 43 = 1.23 : 1	....	....	..	38 : 32 : 37
<i>Bahdhan</i>							
Réservoir souterrain	855	83 : 18 = 4.61 : 1	....	43 : 22 = 2.18 : 1	58 : 42 = 1.38 : 1	0.83 : 1	43 : 33 : 47
Petite rivière à l'eau saumâtre	874	....	....	....	....	..	42 : 40 : 50

Basin	798	88 : 20 = 4.40 : 1	....	....	....	..	43 : 33 : 40
Mare de rivière temporaire	779	73 : 20 = 3.65 : 1	75 : 50 = 1.50 : 1	45 : 20 = 2.25 : 1	58 : 41 = 1.41 : 1	0.78 : 1	43 : 33 : 37
Puits	769	80 : 17 = 4.70 : 1	67 : 50 = 1.34 : 1	....	....	..	35 : 30 : 31
<i>Bender Chalipour</i>							
Citerne d'eau douce	798	87 : 18 = 4.83 : 1	70 : 50 = 1.40 : 1	47 : 20 = 2.35 : 1	58 : 40 = 1.45 : 1	0.81 : 1	38 : 30 : 42
Mare à l'eau saumâtre	826	....	....	....	....	..	47 : 30 : 42
<i>Bourn</i>							
Source	792	....	....	....	....	..	33 : 37 : 42
Mare de rivière entre	792	....	....	....	....	..	42 : X : X
Bourn et Fal							
<i>Chouch (Suez)</i>							
Fosse près de la gare	789	90 : 20 = 4.50 : 1	72 : 48 = 1.50 : 1	67 : 33 = 2.03 : 1	77 : 55 = 1.40 : 1	0.87 : 1	43 : 33 : 42
Marécage près du village	788	92 : 19 = 4.84 : 1	68 : 50 = 1.36 : 1	....	....	..	42 : 30 : 37
<i>Chouchter</i>							
Mare dans le lit d'une petite rivière	817	83 : 20 = 4.15 : 1	57 : 42 = 1.36 : 1	....	....	..	38 : 25 : 33
<i>Djam</i>							
Rivière entre	997	72 : 18 = 4 : 1	60 : 43 = 1.39 : 1	....	....	..	33 : 25 : 38
Djam et Makkou							
<i>Djarkan</i>							
Mare près d'un canal	817	87 : 19 = 4.58 : 1	68 : 45 = 1.51 : 1	....	....	..	42 : 28 : 33
<i>Frouzabad</i>							
Bassin	760	....	....	....	....	..	33 : 28 : 29
<i>Tang-Gaz</i>							
Rivière	732	72 : 16 = 4.50 : 1	62 : 52 = 1.19 : 1	....	....	..	33 : 30 : 40
	741	70 : 18 = 3.89 : 1	....	38 : 17 = 2.24 : 1	53 : 33 = 1.60 : 1	0.72 : 1	37 : X : X
<i>Chalroud</i>							
Bassin	902	80 : 18 = 4.44 : 1	87 : 42 = 2.07 : 1	....	....	..	50 : 33 : 37
Autre bassin	807	80 : 20 = 4 : 1	67 : 47 = 1.43 : 1	....	....	..	50 : 25 : 37
Marécage près d'un canal	931	103 : 21 = 4.90 : 1	83 : 52 = 1.59 : 1	....	....	..	47 : 33 : 42
Patite mare à feuilles décomposées	807	83 : 19 = 4.37 : 1	70 : 50 = 1.40 : 1	....	....	..	40 : 27 : 30

*Eucyclops serrulatus* (Fischer) ♂—contd.

Localité.	Longueur. μ	Furca Long. : larg.	Furca Solé ap. int. : solé ap. ext.	Enp. 4. Art. term. Long. : larg.	Enp. 4. Ep. ap. int. : ép. ap. ext.	Enp. 4. Art. term. : ép. ap. int.	Sixième patte Epine : solé mcd. solé ext.
<i>Geyan</i> Mare sans végétation	831	100 : 20 = 5 : 1	70 : 50 = 1.40 : 1	50 : 23 = 2.17 : 1	60 : 44 = 1.50 : 1	0.76 : 1	40 : 35 : 43
Autre mare sans végétation	870	92 : 20 = 4.60 : 1	75 : 47 = 1.59 : 1	....	....	..	43 : 37 : 47
Basin	936	107 : 20 = 5.35 : 1	....	....	....	..	43 : 32 : 37
Mare	627	90 : 20 = 4.50 : 1	62 : 48 = 1.29 : 1	....	....	..	42 : 27 : 37
<i>Kerédy</i> Mare à feuilles décomposées	884	82 : 20 = 4.10 : 1	....	52 : 20 = 2.60 : 1	53 : 40 = 1.32 : 1	0.98 : 1	45 : 35 : 43
Petite mare eutrophique	912	75 : 18 = 4.17 : 1	....	40 : X = X : 1	42 : X = X : 1	0.95 : 1	43 : 33 : 50
Mare de rivière	931	83 : 22 = 3.77 : 1	....	....	....	..	42 : 33 : 33
<i>Pahlevi</i> Lagune	760	85 : 20 = 4.25 : 1	67 : 45 = 1.49 : 1	....	....	..	42 : 33 : 38
<i>Ramsar</i> Mare	807	....	....	....	....	..	40 : 33 : 42
Marais	813	....	....	....	....	..	40 : 33 : 42
Mare près d'un torrent	798	83 : 18 = 4.61 : 1	67 : 37 = 1.81 : 1	47 : 23 = 2.04 : 1	58 : 42 = 1.38 : 1	0.81 : 1	42 : 33 : 33
Petite étang	884	97 : 22 = 4.41 : 1	75 : 50 = 1.50 : 1	50 : 20 = 2.50 : 1	65 : 43 = 1.51 : 1	0.77 : 1	38 : 38 : 50
<i>Rech</i> Ruisseau	759	88 : 20 = 4.40 : 1	....	....	....	..	37 : 35 : X
<i>Seri</i> Fosse près de la voie ferrée	855	....	....	....	....	..	40 : 33 : 40
Rizière	760	....	....	....	....	..	40 : 27 : X

*Eucyclops agilooides* (Sars).

Longueur. μ	Furca. Long. : larg.	Furca. Sole ap. int. : sole ap. ext.	Enp. 4 Art. term. Long. : larg.	Enp. 4 Ep. ap. int. : Ep. ap. ext.	Enp. 4 Art. term. : Ep. ap. int.	Cinquième patte Epine : sole méd. (larg. approx.).	Sixième patte Epine.
♀ 988	113 : 23 = 4.91 : 1	77 : 58 = 1.33 : 1	60 : 27 = 2.22 : 1	61 : 44 = 1.39 : 1	0.88 : 1	1.6 : 1	..
♀ 855	100 : 22 = 4.55 : 1	83 : 50 = 1.66 : 1	55 : 27 = 2.04 : 1	60 : 42 = 1.43 : 1	0.92 : 1	1.6 : 1	..
♀ 1045	113 : 24 = 4.70 : 1	83 : 55 = 1.50 : 1	57 : 27 = 2.11 : 1	65 : 50 = 1.30 : 1	0.88 : 1	2.2 : 1	..
♂ 684	58 : 18 = 3.22 : 1	....	....	..	....	..	25
♂ 732	....	....	....	..	....	..	23
♂ 732	55 : 18 = 3.06 : 1	58 : 37 = 1.57 : 1	42 : 19 = 2.21 : 1	47 : 33 = 1.42 : 1	....	..	92

*Eucyclops serrulatus* (Fischer) ?

Localité.	Longueur. μ	Furca. Long. : larg.	Furca Sole ap. int. sole ap. ext.	Enp. 4 Art. term. Long. : larg.	Enp. 4. Ep. ap. int. : Ep. ap. ext.	Enp. 4 Art. term. : Ep. ap. int.	Cinquième patte Epine : sole méd. (larg. approx.).	Sixième patte Epine : sole méd. : sole ext.
Isfahan	♀ 1330	184 : 32 = 5.75 : 1	100 : 93 = 1.08 : 1	75 : 39 = 2.50 : 1	87 : 65 = 1.34 : 1	0.86 : 1	3.4 : 1	..
	♀ 1178	167 : 25 = 6.68 : 1	100 : 95 = 1.05 : 1	75 : 32 = 2.34 : 1	83 : 70 = 1.19 : 1	0.90 : 1	3.1 : 1	..
	♂ 984	105 : 22 = 4.77 : 1	67 : 52 = 1.29 : 1	52 : 24 = 2.17 : 1	62 : 41 = 1.51 : 1	0.84 : 1	..	47 : 37 : 43
	♂ 969	103 : 22 = 4.68 : 1	70 : 53 = 1.32 : 1	..	....	..	..	47 : 33 : 42
	♂ 965	103 : 20 = 5.01 : 1	70 : 47 = 1.49 : 1	52 : 25 = 2.08 : 1	63 : 47 = 1.34 : 1	0.83 : 1	..	44 : 37 : 43
Lovon Lac Maclaren (Suède)	♀ 1349	190 : 30 = 6.33 : 1	92 : 85 = 1.08 : 1	82 : 33 = 2.48 : 1	98 : 63 = 1.56 : 1	0.84 : 1	..	..
	♀ 1368	200 : 27 = 7.40 : 1	107 : 83 = 1.29 : 1	92 : 33 = 2.78 : 1	93 : 65 = 1.43 : 1	0.99 : 1	..	..

*Eucyclops spenatus* (Lilljeborg).

♀ 1349	190 : 30 = 6.33 : 1	92 : 85 = 1.08 : 1	82 : 33 = 2.48 : 1	98 : 63 = 1.56 : 1	0.84 : 1	..	..
♀ 1368	200 : 27 = 7.40 : 1	107 : 83 = 1.29 : 1	92 : 33 = 2.78 : 1	93 : 65 = 1.43 : 1	0.99 : 1	..	..

*Eucyclops euacanthus* (Sars).

Localité.	Longueur. μ	Furca. Long.: larg.	Furca. Sole ap. int.: sole ap. ext.	Eup. 4. Art. term. Long.: larg.	Eup. 4. Ep. ap. int.: ép. ap. ext.	Eup. 4. Art. term.: ép. ap. int.	Cinquième patte. Epine: sole méd. (larg. approx.).	Sixième patte. Epine: sole méd. sole ext.
Baba Hadji	♀ 1108	142: 27 = 5.26: 1	138: 75 = 1.84: 1	72: 20 = 2.77: 1	85: 59 = 1.46: 1	0.85: 1	1.6: 1	..
Khora	♂ 712	67: 17 = 3.94: 1	53: 30 = 1.77: 1	..	..	..	..	25: 27: 33
	♂ 684	67: 10 = 4.19: 1	..	..	..	..	..	23: 25: 33
	♂ ..	67: 18 = 3.72: 1	..	..	..	..	..	27: 27: 42

*Eucyclops macruroides* (Lilljeborg).

Longueur. μ	Furca. Long.: larg.	Furca. Sole ap. int.: sole ap. ext.	Eup. 4. Art. term. Long.: larg.	Eup. 4. Ep. ap. int.: ép. ap. ext.	Eup. 4. Art. term.: ép. ap. int.	Cinquième patte. Epine: sole méd. (larg. approx.).	Sixième patte. Epine: sole méd.: sole ext.
♀ 1140	184: 27 = 6.81: 1	92: 76 = 1.21: 1	73: 35 = 2.09: 1	84: 59 = 1.40: 1	0.87: 1	1.0: 1	..
1092	170: 23 = 7.39: 1	60: 69 = 1.39: 1	77: 30 = 2.57: 1	82: 58 = 1.43: 1	0.9: 1	1.3: 1	..
♀ 1055	170: 22 = 7.73: 1	100: 70 = 1.43: 1	..	....	..	..	..
♀ 1074	173: 25 = 6.92: 1	102: 77 = 1.32: 1	75: 28 = 2.68: 1	83: 60 = 1.38: 1	0.90: 1	1.2: 1	..
♂ 789	120: 16 = 7.50: 1	70: 50 = 1.40: 1	50: 22 = 2.27: 1	58: 40 = 1.45: 1	0.86: 1	..	27: 30: 42

## NEMATODES PARASITIC IN *GRYLLOTALPA*.

By M. A. BASIR.

(Department of Zoology, Muslim University, Aligarh, U. P., India.)

During recent years nematodes of insects have received renewed interest because of the possibility of their use in the biological control of insect pests. In this connection several successful experiments have already been performed, but most of them are still in the experimental stage. In India little work has been done on insect nematodes and unless a thorough survey is made of the various nematodes which infest the insects of the land, the possibilities of their biological importance in the control of insects cannot be assessed. With this end in view the author has started making a general survey of nematode parasites of insects of this country.

A very large number of *Gryllotalpae* were dissected from the Aligarh district. Nearly all of them were found to be infected with one or more species of nematodes. All the nematodes found are Oxyurid worms belonging to the subfamily Thelastomatinae. The material was found to consist of five different kinds of worms. Four of them were found to represent four new genera for which the following names have been proposed :-

*Gryllocola gryllocola*, gen. et sp. nov.

*Gryllophila gryllophila*, gen. et sp. nov.

*Talpicola talpicola*, gen. et sp. nov.

*Mirzaiella asiatica*, gen. et sp. nov.

One worm closely resembles *Periplaneticola mirzaia*, a genus described by the author in an earlier paper (1940), but it differs from that species in certain characters. The name *Periplaneticola periplaneticola*, sp. nov. is proposed for it.

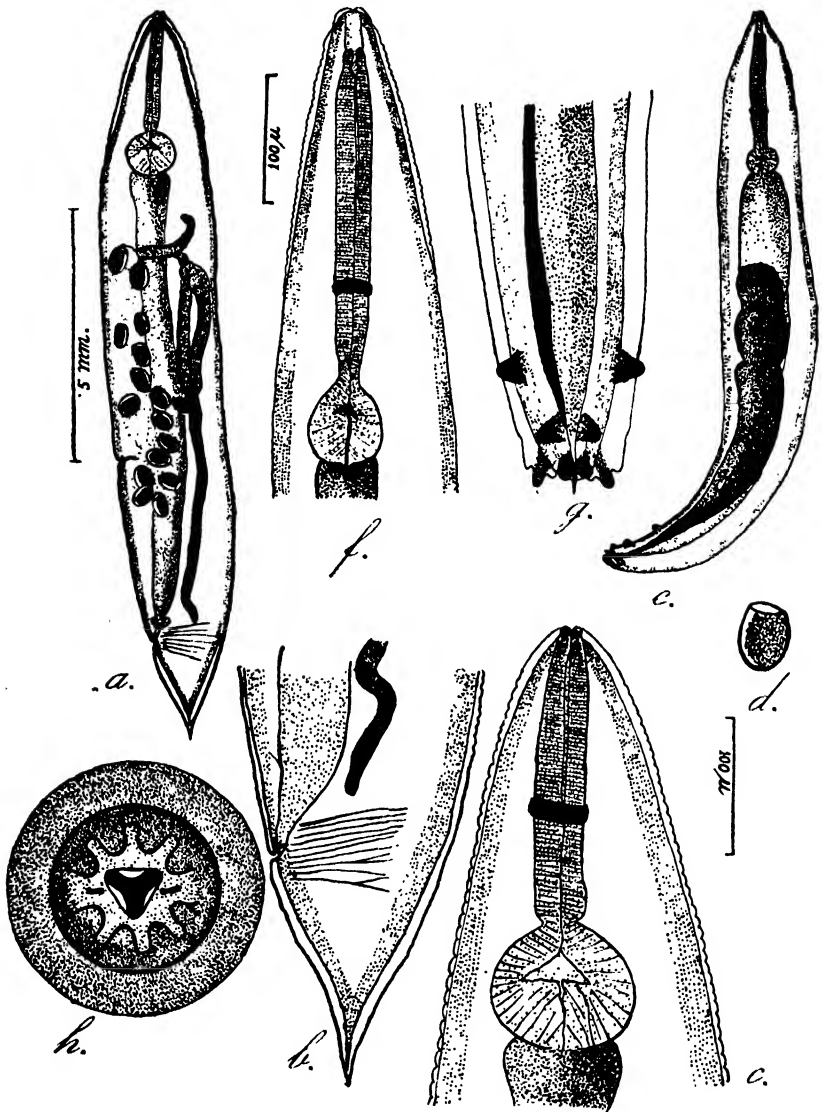
### ***Gryllocola*, gen. nov.**

*Generic diagnosis*.--Thelastomatinae: mouth opening prismoidal, surrounded by eight submedian labiopapillae. Cervical and caudal alae present. Oesophagus consisting of an anterior club-shaped part set off from the posterior valvular bulb by a narrow isthmus. Intestine dilated anteriorly to form a slight cardia. Vulva two-third of the body length from the anterior end. Tail of female conical. Tail of male truncated, bearing four pairs of caudal papillae; one pair of large sub-ventral preanal papillae, one pair of medioventral preanal papillae, one pair of adanal papillae, and one pair of postanal subdorsal papillae. Ovaries two; uteri divergent. Eggs oval with a conspicuous polar cap. Spicule single.

*Type species*.--*Gryllocola gryllocola*, sp. nov.

*Specific description*.--*Gryllocola*.

*Male* (Text-fig. 1 *e-g*).—1.08 mm. long by 150  $\mu$  wide. Cervical and caudal alae present. Cuticular striations present only in the cervical region, anterior to the nerve ring. First two annules very large,



TEXT-FIG. 1.—*Gryllocola gryllocola*, gen. et sp. nov.

*a.* Adult female entire. *b.* Female, tail, lateral view. *c.* Female, oesophageal region. *d.* Eggs. *e.* Male, entire, lateral view. *f.* Male, oesophageal region. *g.* Male, caudal region, ventral view. *h.* Female, head, en face view.

each about 18  $\mu$  wide, remaining annules 6  $\mu$  apart. Buccal cavity long and cylindrical, 30  $\mu$  deep by 15  $\mu$  wide. Oesophagus 310  $\mu$  long, consisting of a corpus 245  $\mu$  long by 25  $\mu$  wide, an isthmus 16  $\mu$  long by 10  $\mu$  wide and a posterior valvular bulb 65  $\mu$  long by 55  $\mu$  wide. Nerve ring 150  $\mu$  from the anterior end of body. Excretory pore not

observed. Anus near the posterior extremity, ventrally situated. Tail completely truncated. Caudal papillae consisting of one pair of large subventral preanal, one pair of medioventral preanal, one pair of adanal and one pair of subdorsal postanal papillae. Subventral alae present. Testis single. One spicule with a broad and blunt head, 18  $\mu$  long.

*Female*: (Text-fig. 1 *a-d, h*).—1.35 mm. long by 180  $\mu$  wide. Cuticle inconspicuously striated; striations 6  $\mu$  apart. Cervical and caudal alae present. Oral opening prismoidal with three inner cuticular projections, surrounded by eight submedian labiopapillae. Amphids or lateral organs appear as small circular openings. Buccal cavity not conspicuous. Oesophagus 310  $\mu$  long, consisting of a corpus 220  $\mu$  long by 27  $\mu$  wide, an isthmus represented by a narrow constriction 20  $\mu$  wide, and a posterior valvular bulb 90  $\mu$  long by 80  $\mu$  broad. Nerve ring 150  $\mu$  from the anterior end of body. Excretory pore not observed. Intestine enlarged anteriorly to form a slight cardia. Anus 170  $\mu$  from the posterior end of body. Tail conical. Vulva 850  $\mu$  from the anterior end of body. Ovaries two; uteri divergent. Eggs approximately oval, 45  $\mu$  to 50  $\mu$  long by 27  $\mu$  wide, with a conspicuous polar cap.

*Host*.—*Gryllotalpa*, sp.

*Location*.—Intestine (rectum).

*Type locality*.—Aligarh (Northern India).

*Type specimen*.—(Reg. No. W3456/1) is deposited in the Zoological Survey of India (*Ind. Mus.*), Calcutta.

### **Gryllophila**, gen. nov.

*Generic diagnosis*.—Thelastomatinae: Mouth opening triangular, surrounded by a circumoral elevation and eight labiopapillae. Oesophagus consisting of an anterior corpus, an isthmus distinctly set off from the corpus and a posterior valvular bulb. Intestine dilated anteriorly to form a big cardia. Vulva 77 per cent of the body length from the anterior end. Ovaries two; uteri parallel. Eggs ellipsoidal; segmentation begins at the time of deposition. Tail of female conically attenuated. Tail of male attenuated, ending in a short pointed appendage which is abruptly set off from the body. Spicule single.

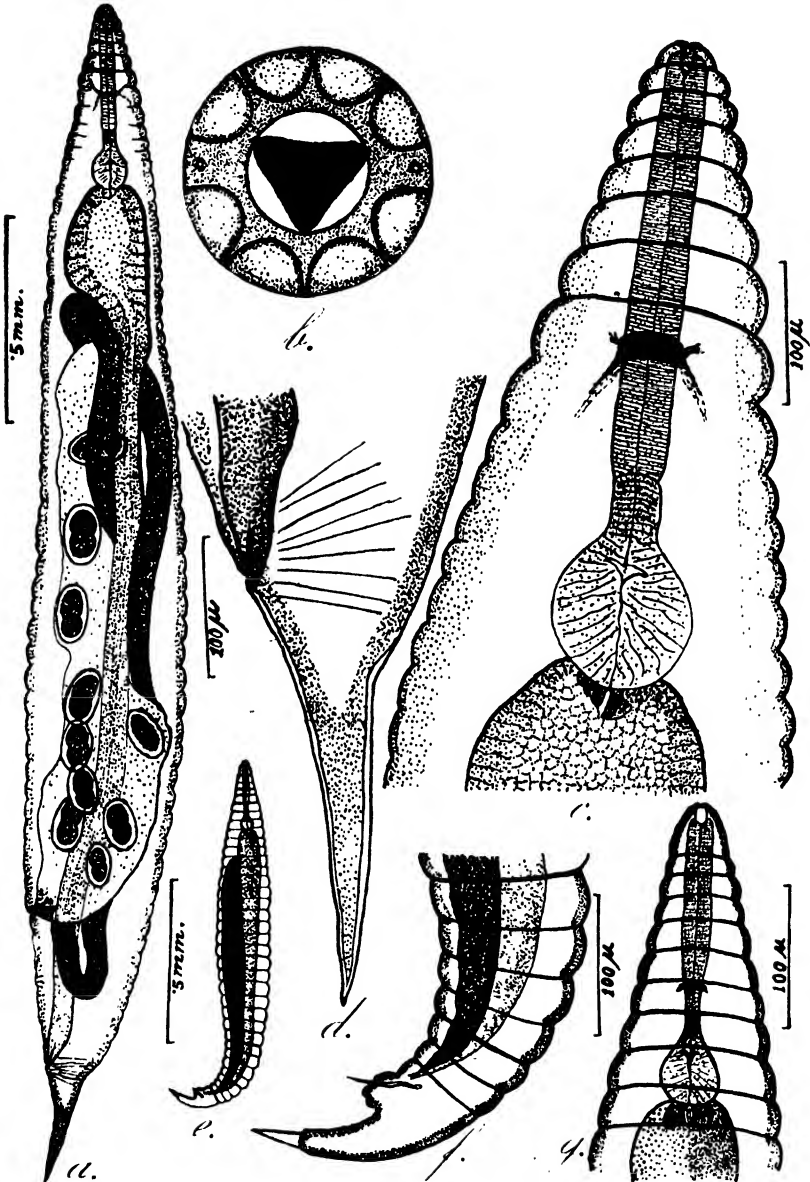
*Type species*.—*Gryllophila gryllophila*, sp. nov.

*Specific description*.—*Gryllophila*:

*Male*: (Text-fig. 2 *e-g*).—1.17 mm. long by 170  $\mu$  wide. Body annulated throughout its whole length. First annule very big, 40  $\mu$  wide, second 15  $\mu$  wide and the third 18  $\mu$  wide. The following annules continually and regularly increase in width till about the middle of the body some of them reach the width of 40  $\mu$ . Posteriorly they regularly decrease in size, the posterior most annule being only 22  $\mu$  wide. Buccal cavity cylindrical, 12  $\mu$  deep by 8  $\mu$  wide. Oesophagus 200  $\mu$  long, consisting of a corpus 115  $\mu$  long by 20  $\mu$  in maximum width, an isthmus 40  $\mu$  long by 10  $\mu$  wide and a posterior valvular bulb 45  $\mu$  long by 40  $\mu$  wide. Nerve ring 125  $\mu$  from the anterior end of body. Excretory pore not observed. Anus 115  $\mu$  from the posterior end of body. Tail attenuated, ending in a short pointed appendage which is abruptly set off from the body. One spicule, 50  $\mu$  long.



*Female*: (Text-fig. 2 *a-d*).—2.8 mm. long by 350  $\mu$  in maximum width. Cuticle conspicuously striated. First annule 17  $\mu$  wide; width



TEXT-FIG. 2. *Gryllophila gryllophila*, gen. et sp. nov.

*a.* Adult female, entire, lateral view. *b.* Female, head, en face view. *c.* Female oesophageal region. *d.* Female, tail, lateral view. *e.* Male, entire, lateral view. *f.* Male, caudal region, lateral view. *g.* Male, oesophageal region.

of the following annules increasing till it reaches its maximum in the ninth annule which is 50  $\mu$  wide. Posterior to the ninth annule a width of 30  $\mu$  is regularly maintained till we reach the position of the vulva

behind which the width of the annules again decreases to  $10\ \mu$ . Oral opening triangular, surrounded by a circumoral elevation and eight submedian labiopapillae. Amphids present in the form of small circular openings. Buccal cavity cylindrical,  $20\ \mu$  deep by  $10\ \mu$  wide. Oesophagus  $453\ \mu$  long, consisting of a corpus  $300\ \mu$  long by  $40\ \mu$  wide, an isthmus  $43\ \mu$  long by  $35\ \mu$  wide, and a posterior valvular bulb  $110\ \mu$  long, by  $100\ \mu$  wide. Nerve ring  $210\ \mu$  from the anterior end of body. Excretory pore not observed. Intestine dilated anteriorly to form a big cardia. Anus  $320\ \mu$  from the posterior end of body. Tail conically attenuated. Vulva in the posterior third of the body,  $2.17\ \text{mm}$ . from the anterior end. Ovaries two; uteri parallel. Eggs ellipsoidal.  $150\ \mu$  long by  $80\ \mu$  wide; segmentation begins before deposition.

*Host*.—*Gryllotalpa*, sp.

*Location*.—Intestine (rectum).

*Type locality*.—Aligarh (Northern India).

*Type specimen*.—(Reg. No. W3457.1) is deposited in the Zoological Survey of India (*Ind. Mus.*), Calcutta.

### **Talpicola**, gen. nov.

*Generic diagnosis*. Thelastomatinae: *Male* unknown.

*Female* with mouth opening sub-triangular, surrounded by eight labiopapillae. Lateral alae present. Oesophagus consisting of a cylindrical corpus followed by a very short isthmus not distinctly separated either from the corpus or from the following posterior valvular bulb. Buccal cavity broad and cylindrical. Excretory pore much behind the base of oesophagus. Tail conical. Vulva near middle of body. Vagina directed anteriorly. Ovaries two; uteri divergent. Eggs oval, with a conspicuous polar cap.

*Type species*.—*Talpicola talpicola*, sp. nov.

*Specific description*.—*Male* unknown.

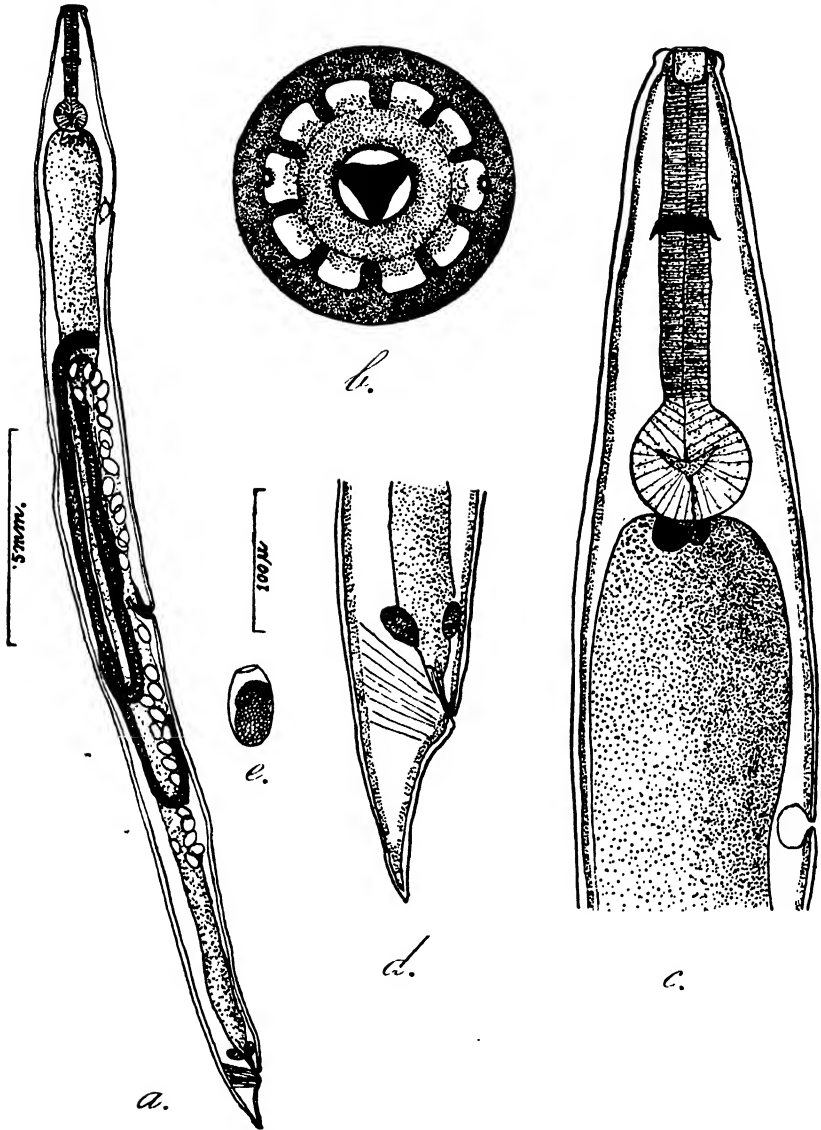
*Female*: (Text-fig. 3 a-e).— $2.7\ \text{mm}$ . long by  $170\ \mu$  wide. Lateral alae present. Body not striated. Oral opening sub-triangular, surrounded by eight submedian labiopapillae. Amphids appear as small circular openings. Buccal cavity  $25\ \mu$  deep by  $22\ \mu$  wide. Oesophagus  $325\ \mu$  long, consisting of a cylindrical corpus  $235\ \mu$  long by  $35\ \mu$  wide, an isthmus  $10\ \mu$  long by  $30\ \mu$  wide not distinctly set off, and a posterior valvular bulb  $80\ \mu$  long by  $85\ \mu$  wide. Nerve ring  $120\ \mu$  from the anterior end of body, situated near the middle of corpus. Excretory pore posterior to base of oesophagus,  $550\ \mu$  from the anterior end of body. Intestine enlarged anteriorly to form a cardia. Anus  $135\ \mu$  from the posterior end of body. Tail conical. Vulva near middle of body,  $1.42\ \text{mm}$ . from the anterior end. Vagina directed anteriorly. Ovaries two; uteri divergent. Eggs oval,  $55\ \mu$  long by  $30\ \mu$  wide, with a conspicuous polar cap; segmentation begins before deposition.

*Host*.—*Gryllotalpa*, sp.

*Location*.—Intestine (rectum).

*Type locality*.—Aligarh (Northern India).

*Type specimen*.—(Reg. No. W3458/1) is deposited in the Zoological Survey of India (Ind. Mus.), Calcutta.



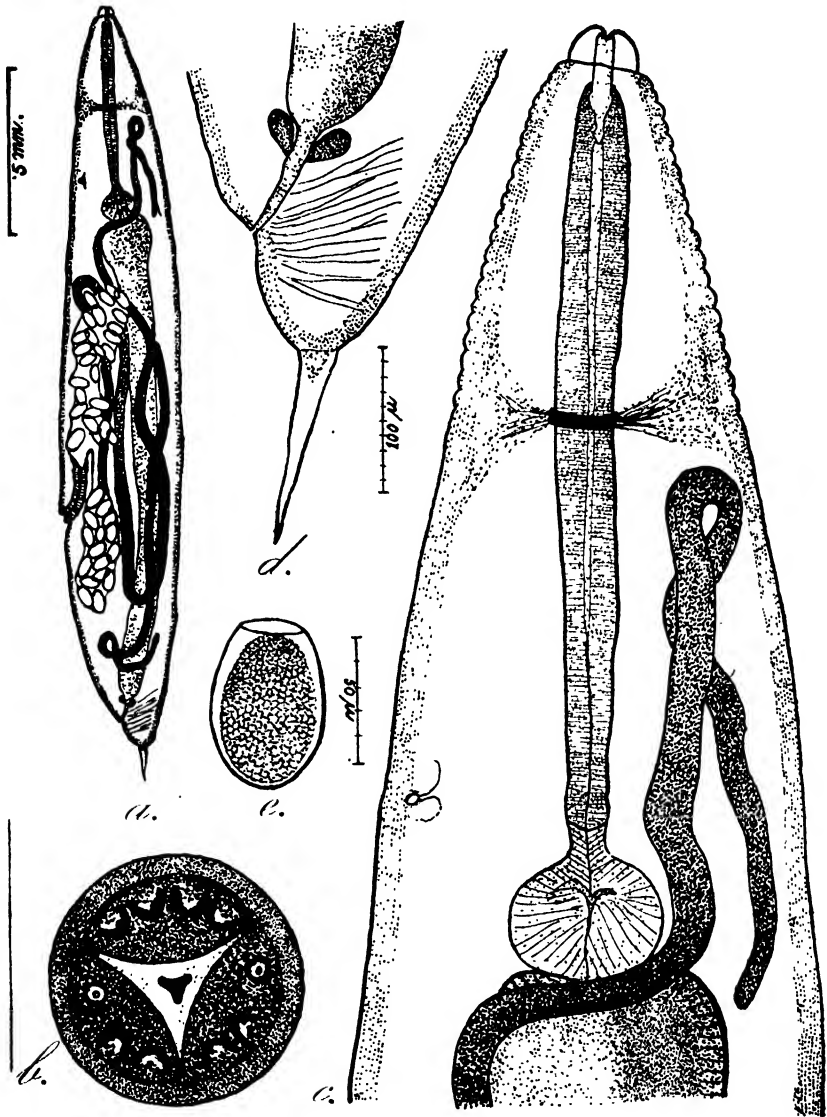
TEXT-FIG. 3. —*Talpicola talpicola*, gen. et sp. nov.

a. Adult female, entire, lateral view. b. Female, head, en face view. c. Female, anterior region. d. Female, tail, lateral view. e. Egg.

### Mirzaiella, gen. nov.

*Generic diagnosis*.—Thelastomatinae: Oral opening small and sub-triangular, surrounded by three well developed lips; the dorsal lip bears four papillae on its external surface and the ventro-lateral lips bear two papillae each. Amphids are present, opening externally near

the dorsal part of the ventro-lateral lips. Cuticle striated only anterior to the nerve ring. Buccal cavity long, partly covered by the oesophagus. Oesophagus very long, occupying more than 25 per cent of the body length, consisting of an anterior corpus, an isthmus and a posterior valvular bulb. Excretory pore anterior to base of oesophagus. Intestine dilated anteriorly to form a big cardia. Tail short and rounded.



TEXT-FIG. 4.—*Mirzaiella asiatica*, gen. et sp. nov.

a. Adult female, entire, lateral view. b. Female, head, en face view. c. Female, oesophageal region. d. Female, tail, lateral view. e. Egg.

bearing a caudal appendage which is distinctly set off from the body. Vulva two-third of the body length from the anterior end. Vagina

long and muscular, directed anteriorly. Ovaries two; uteri divergent. Eggs oval, with a conspicuous polar cap.

*Type species*.—*Mirzaiella asiatica*, sp. nov.

*Specific description*.—*Mirzaiella*: *Male* unknown.

*Female*: (Text-fig. 4 *a-c*). 2.2 mm. long by 360  $\mu$  wide. Cuticle transversely striated only anterior to the nerve ring. Anterior annules 11  $\mu$  wide and posterior ones up to 15  $\mu$  wide. Mouth small and sub-triangular, surrounded by three well developed lips; the dorsal lip bears four papillae on its external surface and the ventro-lateral lips bear two papillae each. Amphids open externally towards the dorsal part of the ventro-lateral lips. Buccal cavity 75  $\mu$  long by 11  $\mu$  wide. Oesophagus 620  $\mu$  long, consisting of a corpus 510  $\mu$  long by 40  $\mu$  in maximum width, an isthmus 22  $\mu$  long by 22  $\mu$  wide and a posterior valvular bulb 85  $\mu$  long by 108  $\mu$  wide. Nerve ring 270  $\mu$  from the anterior end of body. Excretory pore anterior to base of oesophagus, 550  $\mu$  from the anterior end of body. Intestine dilated anteriorly to form a big cardia. Anus 215  $\mu$  from the posterior end of body. Tail short and rounded, bearing a caudal appendage 130  $\mu$  long, the latter being longer in younger females. Vulva 1.55 mm. from the anterior end of body. Vagina long and muscular, directed anteriorly. Ovaries two; uteri divergent. Eggs oval, 70  $\mu$  long by 45  $\mu$  wide, with a conspicuous polar cap.

*Host*.—*Gryllotalpa*, sp.

*Location*.—Intestine (rectum).

*Type locality*.—Aligarh (Northern India).

*Type specimen*.—(Reg. No. W3459/1) is deposited in the Zoological Survey of India (*Ind. Mus.*), Calcutta.

#### Genus **Periplaneticola** Basir, 1940.

*Generic diagnosis*.—*Thelastomatinae*: *Male* unknown.

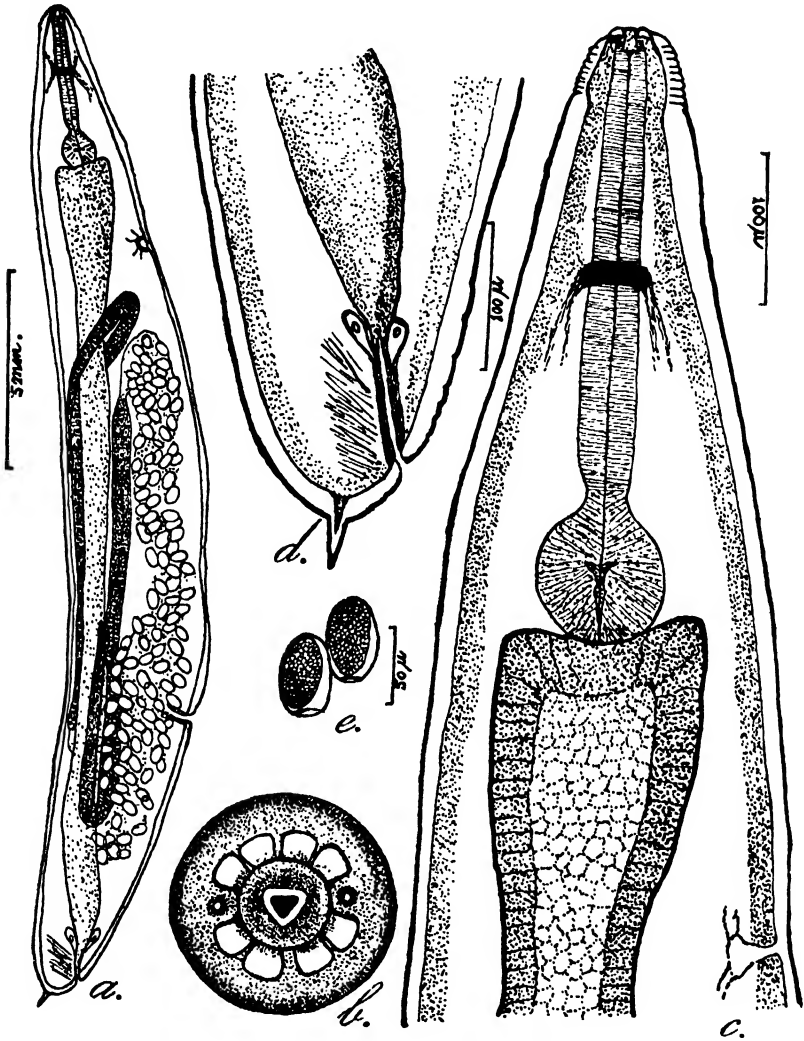
*Female* with mouth opening sub-triangular, surrounded by a circumoral elevation and eight labiopapillae. Amphids appear as small circular openings. Oesophagus consisting of an anterior corpus followed by a distinct isthmus and a posterior valvular bulb. Nerve ring about two-third of the length of corpus from its anterior end. Tail of female very characteristic; short and blunt, with a very small caudal appendage distinctly set off from the body. Vulva two-third or more of the body length from the anterior end. Ovaries two; uteri divergent. Eggs oval, with a conspicuous polar cap.

#### **Periplaneticola periplaneticola**, sp. nov.

*Specific description*.—*Periplaneticola*: *Male* unknown.

*Female*: (Text-fig. 5 *a-c*). —2.6 mm. long by 350  $\mu$  in maximum width. Cuticle striated only in the cervical region; in all only nine annules present. First annule 15  $\mu$  wide, remaining annules 8.5  $\mu$  wide each. Lateral alae, present. Oral opening sub-triangular, surrounded by a circumoral elevation and eight labiopapillae. Amphids appear as small circular openings. Buccal cavity cylindrical, partly enveloped by the oesophagus, 18  $\mu$  deep by 10  $\mu$  wide. Oesophagus 400  $\mu$  long, consisting of a

corpus 295  $\mu$  long by 35  $\mu$  wide, an isthmus 15  $\mu$  long by 28  $\mu$  wide and a posterior valvular bulb, 90  $\mu$  long by 85  $\mu$  wide. Nerve ring 140  $\mu$



TEXT-FIG. 5.—*Periplaneticola periplaneticola*, sp. nov.

a. Adult female, entire, lateral view. b. Female, head, en face view. c. Female, anterior region. d. Female, tail, lateral view. e. Egg.

from the anterior end of body. Excretory pore much behind the base of oesophagus, 610  $\mu$  from the anterior end of body. Intestine enlarged anteriorly to form a slight cardia. Anus 90  $\mu$  from the posterior end of body. Tail short and blunt with a very small pointed caudal appendage, 35  $\mu$  long, distinctly set off from the body. Vulva 1.85 mm. from the anterior end of body, 71 per cent of the body length from the anterior end. Ovaries two; uteri divergent. Eggs oval, 55  $\mu$  long by 35  $\mu$  wide, with a conspicuous polar cap.

*Periplaneticola* was described as a new genus by the writer in the paper cited and one species *Periplaneticola mirzaia*, was described from the intestine of *Periplaneta americana*. Since that description was based on a single non-gravid female, it could not be complete. No eggs were seen and the form of oral opening and head papillae could not be described. The present specimens were obtained from *Gryllotalpa* and resemble *Periplaneticola mirzaia* to a great extent; but there are certain characters which do not allow the two to be put together under the same species. The absence of alae, the extent of cuticular striations on the body, and the position of vulva in *Periplaneticola mirzaia*, are characters sufficient enough to separate the two as distinct species.

*Host*.—*Gryllotalpa* sp.

*Location*.—Intestine (rectum).

*Type locality*.—Aligarh (Northern India).

*Type specimen*.—(Reg. No. W3460/1) is deposited in the Zoological Survey of India (*Ind. Mus.*), Calcutta.

*Key to the species of the genus Periplaneticola.*

1. Lateral alae absent. Cuticle striated throughout the whole length of the body. Vulva 66 per cent of the body length from the anterior end .. .. . *P. mirzaia*.
2. Lateral alae present. Cuticle striated only in the cephalic region. Vulva 71 per cent of the body length from the anterior end .. .. . *P. periplaneticola*.

*Key to the genera of the sub-family Thelastomatinae.*

1. Corpus of oesophagus terminated posteriorly by a pronounced swelling at least in female .. .. . 2  
Corpus of oesophagus not terminated by a pronounced swelling .. .. . 6
2. Anterior and posterior parts of corpus not distinctly set off .. .. . *Aorurus*.  
Anterior and posterior parts of corpus distinctly set off .. .. . 3
3. Corpus terminated by a subcylindrical swelling .. .. . *Leidynema*.  
Corpus terminated by an ovoid or subspherical swelling .. .. . 4
4. Corpus terminated by a subspherical swelling .. .. . *Leidynemella*.  
Corpus terminated by an ovoid swelling .. .. . 5
5. Tail of female filiform .. .. . *Hammerschmidtella*.  
Tail of female conical .. .. . *Galebiella*.
6. Eggs encapsulated or covered with spiral threads (often in two's or three's) .. .. . 7  
Eggs not covered as above .. .. . 8
7. Eggs covered by spiral threads .. .. . *Pseudonymus*.  
Eggs encapsulated, not covered by spiral threads .. .. . *Binema*.
8. Corpus of oesophagus of female very short .. .. . 9  
Corpus of oesophagus of female not very short .. .. . 11
9. Vulva near middle of body .. .. . *Talpicola*.  
Vulva much posterior to middle of body .. .. . 10
10. Tail of female conical .. .. . *Blatticola*.  
Tail of female attenuated .. .. . *Blattelicola*.

11. Corpus distinctly enlarged in form of a sub-spherical swelling at base of buccal cavity .. *Blattophila*.  
Corpus subcylindrical, without any form of enlargement .. .. . 12
12. Tail conical or nearly conical in both sexes .. 13  
Tail filiform, attenuated then delicately filiform, or very sharply set off in both sexes 14
13. Head of female with dorsodorsal and ventro-ventral simple papillae and laterodorsal and lateroventral labiopapillae .. .. *Sevirianoia*.  
Head of female with all eight cephalic papillae in form of labiopapillae .. .. *Cephalobellus*.
14. Female with one ovary .. .. *Galebia*.  
Female with two ovaries .. .. 15
15. Oral opening surrounded by three lips .. 16  
Oral opening not surrounded by three lips .. 17
16. Tail of female filiform or very delicately attenuated .. .. *Fontonema*.  
Tail of female short and round bearing a caudal appendage .. .. *Mirzaiella*.
17. Tail of male extremely short, degenerate .. *Eurycoma*.  
Tail of male delicately attenuated or filiform .. *Thelastoma*.
18. Vulva anterior to middle of body .. .. *Suifunema*.  
Vulva much posterior to middle of body .. 19
19. Uteri divergent .. .. 20  
Uteri parallel .. .. *Gryllophila*.
20. Tail conical .. .. *Gryllocola*.  
Tail short and blunt with a very small caudal appendage attached to it .. .. *Periplaneticola*.

## SUMMARY.

Four new genera and one new species of nematodes have been described from the intestine of *Gryllotalpa* (Gryllidae). All of these are Oxyurid worms belonging to the subfamily Thelastomatinae. The key to the genera at present included in the subfamily Thelastomatinae is given above.

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# ON A COLLECTION OF BIRDS FROM THE HOSHANGABAD DISTRICT (CENTRAL PROVINCES, INDIA).

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## I. INTRODUCTION.

In February-March 1941, a party of the Zoological Survey of India under Dr. B. N. Chopra, and consisting, in addition, of the writer, Mr. K. N. Das and a taxidermist, made a brief zoological survey of the Hoshangabad District in the Central Provinces. Dr. B. Prashad, the Director, was also with the party for a few days. Some 88 bird skins were collected and field-notes taken. The following is a report on this collection. Two skins, one of a warbler, *Phylloscopus*, and the other of a dove, *Streptopelia*, which could not be satisfactorily identified, are not included.

*The Hoshangabad District.*—This district, which is one of the western districts of the Central Provinces, lies between latitudes 21° 53' and 22° 59' N. and longitudes 76° 47' and 78° 44' E. It stretches along the left bank of the Narbada, between the Vindhya Mts. and the Satpura Range of which the Mahadeo Hills may be regarded as a part; it includes a portion of the Satpura Range within its borders. It is a narrow strip of country about 120 miles broad from east to west and roughly 25 miles wide from north to south, and covers an area of 3,676 square miles.

The southern half of the district is occupied by the Satpura Range (highest point about 4,500 feet above sea level) with its moderately dense forests. The northern half consists of open plains which are irrigated by the Narbada and grow largely wheat.

The average temperature varies from about 52° to 108°F. in the plains, while the hills are colder. The average annual rainfall is about 47 inches, being mainly received during five monsoon months, June to October. In the Mahadeo Hills, *e.g.*, Pachmarhi, the rainfall is heavier, averaging 77 inches annually. [For further details and map of the district, see Hora and Nair<sup>1</sup>.]

The collection was made partly in the Mahadeo Hills (Pachmarhi Plateau) and partly in the plains. Ecologically, the two areas are different, and many species found at Pachmarhi are either rare or absent in the plains. Both the areas are treated here together for sake of the convenience.

<sup>1</sup> Hora, S. L. and Nair, K. K., *Rec. Ind. Mus.* XLIII, pp. 361-373 (1941).

*The itinerary.*—The following is the itinerary of the tour :—

## 1. MAHADEO HILLS.

*Pachmarhi.* Feb. 8th to 17th. The Pachmarhi Plateau is 3,500 ft., the surrounding hills about 1,000 ft. higher. We collected on the Pachmarhi Plateau and in the surrounding hills and jungles, especially in the vicinity of hill streams.

*Singanama.* Feb. 18th to 20th. This is a village on the Pachmarhi-Pipariya Road, about 14 miles from Pachmarhi and lying at the foot of the hills. We collected in the forest near R. Denwa. The area is excellent, and very rich in bird life.

## 2. PLAINS.

*Sandia on R. Narbada.*—Feb. 21st. This is a village on the bank of the Narbada, about 12 miles from Pipariya (*infra*). We collected on the river bank.

*Pipariya.*—Feb. 22nd to 23rd. We collected in the fields in the neighbourhood and also around the town.

*Iarsi.*—Feb. 24th to 26th. We collected on the meadows and along the stream not far from the town.

*Handia on R. Narbada.*—Feb. 27th. This is a village on the bank of the Narbada, about 13 miles from Harda (*infra*). We collected on the river bank.

*Harda.*—Feb. 28th to Mar. 5th. We collected around the town, especially along the railway line.

*Ornithology of the District.*—Besides Osmaston's<sup>1</sup> (1922 ; 1936) comprehensive lists of the birds of the Pachmarhi Plateau, there is no noteworthy published account of the birds of the Hoshangabad District. Ali and Whistler<sup>2</sup> (1939 ; 1940) have recently published an account of the birds of the western half of Central India lying just north of the Hoshangabad District, and the present report, though incomplete, may be regarded as complimentary to that account.

*Measurements and sex.*—Measurements were taken as follows :—*Wing* : Chord from the bend of the wing to the tip of the longest primary, with the quills flattened out. *Tail* : From the insertion of the central rectrices in the uropygium to the tip. *Tarsus* : From the tarso-metatarsal joint to the metatarso-digital joint. *Bill* : From the junction of the bill with the skull to the tip—this is as a rule longer than the “exposed culmen”.

The sex was determined in each case by an examination of the gonads. When this was not done, the sex is indicated within brackets.

*Local names.*—These were ascertained for a few birds at Pachmarhi by carefully questioning the local bird-catchers, and are given under the species concerned. The names are in the local Hindi.

<sup>1</sup> Osmaston, B. B., *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 453-459 (1922); and Birds, in *Guide to Pachmarhi*, pp. 62-71 (1936).

<sup>2</sup> Ali, S. and Whistler, H., *Journ. Bombay Nat. Hist. Soc.* XLI, pp. 82-106 (1939); *Journ. Bombay Nat. Hist. Soc.* XLI, pp. 470-488 (1940).

## II. WEIGHTS.

The weights of Indian birds, though recorded in older writings, are seldom recorded in recent reports of collections. The following are the weights of some of the birds in the present collection. The birds were weighed within about 5 hours of being shot. Loss of blood and some feathers constitute a source of error. Nevertheless, it is hoped that the data will provide interesting information which is generally lacking for Indian birds. The systematic value of these weights is, however, not clear. Generally, the weights are in grammes, but those of some of the larger birds are in pounds.

## Ord. PASSERES.

## Fam. CORVIDAE.

*Dendrocitta vagabunda vagabunda* (Lath.)—1 ♀ (near breeding) : 106.6 gms.

## Fam. PARIDAE.

*Parus major maharattarum* Hart.—1 ♂ (non-breeding) : 11.7 gms.

*Macholophus xanthogenys aplonotus* (Bly.)—2 ♂♂ (non-breeding) : 14.1-15.2 gms.

## Fam. SITTIDAE.

*Sitta castanea castanea* Less.—1 ♂ : 12.0 gms.

## Fam. TIMALIIDAE.

*Turdoides somervillii* (subsp. ?)—1 ♀ : 70.8 gms.

*Argya caudata caudata* (Dumont) —2 ♂♂ (near breeding) : 40.4-40.5 gms.

*Chloropsis jerdoni* (Bly.)—1 ♂ (non-breeding) : 24.5 gms.

## Fam. PYCNOTIDAE.

*Molpastes cafer pallidus* Stuart Baker—1 ♀ (non-breeding) : 30.0 gms.

## Fam. TURDIDAE.

*Saxicola caprata bicolor* Sykes—1 (♂) : 13.3 gms.

1 (?) : 12.5 gms.

*Saxicola torquata indica* (Bly.)—1 ♂ (non-breeding) : 13.0 gms.

*Phoenicurus ochruros rufiventris* (Vieil.)—1 (♂) : 16.8 gms.

*Copsychus saularis saularis* (Linn.)—1 ♀ (non-breeding) : 32.1 gms.

*Monticola solitaria pandoo* (Sykes)—2 ♂♂ (non-breeding) : 43.4-46.7 gms.

1 ♀ (non-breeding) : 42.5 gms.

*Myophonus coeruleus horsfieldii* Vig.—1 (sex?) : 120.5 gms.

## Fam. MUSCIPIDAE.

*Culicicapa ceylonensis ceylonensis* (Swain.)—1 (sex?) : 7.2 gms.

*Leucocirca aureola aureola* (Less.)—1 ♀ : 10.0 gms.

## Fam. LANIIDAE.

*Lanius schach erythronotus* (Vig.)—3 ♂♂ (non-breeding) : 34.8-37.2 gms.

## Fam. CAMPEPHAGIDAE.

*Pterocotus peregrinus peregrinus* (Linn.)—2 ad. ♂♂ (non-breeding) : 8.2-8.6 gms.

1 imm. ♂ : 8.5 gms.

*Graucalus macei macei* Less.—2 ♂♂ (non-breeding) : 85.0-89.0 gms.

1 ♀ (non-breeding) : 80.0 gms.

## Fam. DICRURIDAE.

*Dicrurus macrocercus peninsularis* Ticeh.—1 ad. ♀ : 44.1 gms.

1 imm. ♂ : 46.0 gms.

*Dicrurus caerulescens caerulescens* (Linn.)—1 ♂ : 37.4 gms.

## Fam. FRINGILLIDÆ.

*Carpodacus erythrinus roseatus* (Bly.)—1 ♂ (non-breeding) : 20.5 gms.

*Gymnoris xanthocollis xanthocollis* (Burt.)—3 ♂♂ (non-breeding) : 17.0-18.7 gms.  
1 (sex?) : 19.1 gms.

## Fam. MOTACILLIDÆ.

*Motacilla maderaspatensis* J. F. Gm.—1 (sex?) : 35.7 gms.

*Motacilla cinerea caspica* (S. G. Gm.)—1 (sex?) : 17.0 gms.

*Anthus hodgsoni hodgsoni* (Richm.)—1 ♀ : 19.8 gms.

## Fam. ALAUDIDÆ.

*Ammomanes phoenicura phoenicura* (Frank.)—2 ♂♂ (near breeding) : 25.7-27.4 gms.  
1 ♀ (near breeding) : 25.7 gms.

## Fam. NECTARINIIDÆ.

*Leptocoma asiatica asiatica* (Lath.)—1 ♂ (near breeding) : 8.0 gms.

## Ord. CORACIIFORMES.

## Fam. PICIDÆ.

*Dryobates maharattensis* (subsp. ?)—1 (sex?) : 34.2 gms.

## Fam. CAPITONIDÆ.

*Thereiceryx zeylanicus* (subsp. ?)—1 ♂ (near breeding) : 115.5 gms.

## Fam. PSITTACIDÆ.

*Psittacula cyanocephala cyanocephala* (Linn.)—1 (♂) : 64.0 gms  
1 ♀ : (near breeding ?) : 71.4 gms.

## Fam. CORACIDÆ.

*Coracias benghalensis benghalensis* Linn.—1 ♂ (non-breeding) : 121.5 gms.

## Fam. MEROPIDÆ.

*Merops orientalis orientalis* Lath.—2 ♂♂ (non-breeding) : 15.5-17.4 gms.  
1 ♀ (non-breeding) : 16.3 gms.

## Fam. ALCEDINIDÆ.

*Ceryle rudis leucomelanura* Reichen.—1 ♂ (breeding) : 76.6 gms.  
1 ♀ (breeding) : 90.0 gms.

*Alcedo alhis taprobana* Kleinsch.—1 ♂ (near breeding) : 22.7 gms.

*Halcyon smyrnensis smyrnensis* (Linn.)—1 ♂ (non-breeding) : 74.0 gms.

## Fam. UPUPIDÆ.

*Upupa epos ceylonensis* Reichenb.—2 ♂♂ (breeding) : 52.7-55.2 gms.

## Fam. ASIONIDÆ.

*Athene brama indica* (Frank.)—1 ♂ (near breeding) : 111.0 gms.

*Glaucidium radiatum radiatum* (Tick.)—2 ♂♂ (near breeding ?) : 96.5-111.7 gms.  
1 ♀ (near breeding ?) : 112.0 gms.

## Ord. ACCIPETRES.

## Fam. AEGYPTIDÆ.

*Pseudogyps bengalensis* (J. F. Gm.)—1 ♂ (non-breeding) : 10½ lbs.

*Neophron percnopterus ginginianus* (Lath.)—1 (sex?) : 3 lbs.

## Ord. COLUMBAE.

## Fam. COLUMBIDAE.

*Streptopelia orientalis meena* (Sykes)—1 ♂ (non-breeding): 190.7 gms.

*Streptopelia chinensis suratensis* (J. F. Gm.)—1 ♀: 120.4 gms.

*Streptopelia senegalensis cambayensis* (J. F. Gm.)—1 ♂ (non-breeding): 81.0 gms.

*Streptopelia decaocto decaocto* (Frisvald.)—1 ♂ (non-breeding): 82.7 gms.

## Ord. CHARADRIIFORMES.

## Fam. CHARADRIIDAE.

*Lobivanellus indicus indicus* (Bodd.)—1 ♀ (near breeding): 117.0 gms.

## Fam. SCOLOPACIDAE.

*Tringa hypoleucos* Linn.—1 ♂: 43.3 gms.

## III. SYSTEMATIC ACCOUNT.

## Order PASSERES.

## Family CORVIDAE.

***Dendrocitta vagabunda vagabunda*** (Latham).

(The Indian Tree-Pie.)

*Specimen obtained*—

Pachmarhi.—1 ♀, 10.2.41.

*Measurements* (mm.)—

		Wing.	Tail.	Tarsus.	Bill.
1 ♀	.. ..	155	255	32	30

*Colour of bare parts.*—Iris dark brown. Bill ashy black. Legs, feet and claws horny black.

*Field notes.*—Very common on trees at Pachmarhi, going about either singly or in twos and threes. Not seen elsewhere.

The ovary of the ♀ (Feb. 10th) was enlarged and measured 11×7 mm.; the largest egg follicle measured 2×2 mm., suggesting breeding in the near future.

Osmaston (1922, p. 453) says it is very common on the Pachmarhi Plateau and breeds in April-May.

Ali and Whistler (1939, p. 85) recorded it as common in western Central India.

## Family PARIDAE.

***Parus major mahrattarum*** Hartert.

(The Southern Grey Tit.)

*Specimen obtained*—

Around Pachmarhi.—1 ♂, 17.2.41.

*Measurements* (mm.)—

		Wing.	Tail.	Tarsus.	Bill.
1 ♂	.. ..	63	54	28	..

*Colour of bare parts.*—Iris dark chocolate. Bill black. Legs, feet and claws slaty. Pads dirty pale grey.

*Field notes.*—A few seen singly at Pachmarhi.

The testes of the ♂ (Feb. 17th) were in the non-breeding condition and measured  $1 \times 1$  mm.

Osmaston (1922, p. 453) says it is fairly common at Pachmarhi and is resident; the breeding season is not given.

In western Central India, Ali and Whistler (1939, p. 85) found it common; family parties were noted in August and September.

***Machlolophus xanthogenys aplonotus* (Blyth).**

(The Southern Yellow-cheeked Tit.)

*Specimens obtained*—

Pachmarhi.—1♂, 12.2.41; 1♂, 2nd week Feb. 1941.

*Measurements* (mm.)—

		Wing.	Tail.	Tarsus.	Bill.
2 ♂♂	.. ..	69.72	54.59	18.20	13 (1 ♂)

*Field notes.*—Not uncommon at Pachmarhi.

The testes of the two males, were in the non-breeding condition and measured  $1 \times 1$  mm.

Osmaston (1922, p. 453) says it is fairly common in Pachmarhi and breeds in April-May.

In western Central India, Ali and Whistler (1939, p. 86) found it at several places including Chanderi in the Gwalior State which is the most northerly place where *aplnotus* has hitherto been recorded. Courting couples were noted at the end of March and family parties with young in August and September.

Family SITTIDAE.

***Sitta castanea castanea* Lesson.**

(The Chestnut-bellied Nuthatch.)

*Specimen obtained*—

Pachmarhi.—1♂, 10.2.41.

*Measurements* (mm.)—

		Wing.	Tail.	Tarsus.	Bill.
1 ♂	.. ..	72	39	18	19.5

*Colour of bare parts.*—Upper bill horny black, darker at tip; lower bill pale ashy at base, dark horny at tip. Legs, feet and claws horny. Pads pale yellow.

*Field notes.*—One seen at Pachmarhi.

Osmaston (1922, p. 454) says it is common at Pachmarhi and breeds in April-May.

Ali and Whistler (1939, p. 86) found it occurring in pairs or family parties of 3 or 4 in the Indore and Dhar States in western Central India.

NOTE.—On Feb. 12th on the Pachmarhi-Pipariya road about two miles from Pachmarhi I noticed a pair of *Sitta frontalis* sitting on a nest on a tree and evidently feeding the young ones. Unfortunately I could not secure the specimens, but I am certain they were not *S. c. castanea*. However, the fact that Osmaston (1922, p. 454) does not include *S. frontalis* in his Pachmarhi list makes me somewhat uncertain of my identification.

## Family TIMALIIDAE.

**Turdoides somervillei** (subsp.?).

(The Jungle Babbler.)

*Specimen obtained—*

Pachmarhi.—1♀, 10.2.41.

Elsewhere noted at : Harda.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
1 ♀	..	..	107	112	37	25.5

*Colour of bare parts.*—Iris very pale straw-yellow with a central very thin dark brown ring. (Osmaston, 1936, p. 17, gives the iris as white.) Bill pale straw-yellow with a faint fleshy tinge ; tip pale horny. Legs, feet and pads, as bill. Claws fleshy horny.

*Local name.*—"Gayangā."

*Field notes.*—Extremely common at Pachmarhi, usually abounding near habitations and in thin jungle and keeping to bushes and low trees ; occurs in small or big (up to 30 or 40) parties ; feeds on the ground. Fairly common at Harda.

Osmaston (1922, p. 453) too found it common on the Pachmarhi Plateau.

In western Central India, Ali and Whistler (1939, p. 86) found *T. s. orientalis* common in the forests.

**Argya caudata caudata** (Dumont).

(The Common Babbler.)

*Specimens obtained—*

Itarsi.—2♂♂, 25.2.41.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
2 ♂♂	..	..	79-80	109-112	29-30	19-20

*Colour of bare parts.*—Iris brown. Bill earthy brown, tip smoky. Legs, feet and pads dull pink. Claws pale smoky.

*Field notes.*—Fairly common at Itarsi. Seen in groups of 4 or 5 on bushes and low trees.

The testes of two males (Feb. 25th) were enlarged and measured  $6 \times 4$  and  $7 \times 5$  mm., suggesting breeding.

This babbler evidently does not occur on the Pachmarhi Plateau where I did not see it ; nor does Osmaston (1922) record it.

Ali and Whistler (1939, p. 87) found it common in western Central India where birds with mature gonads were found in March, April, August and September, from which these authors suggest that it apparently breeds throughout the year.



**Chloropsis jerdoni** (Blyth).

(Jerdon's Chloropsis.)

*Specimen obtained—*

Around Pachmarhi.—1♂, 14.2.41.

*Measurements* (mm.)—

		Wing.	Tail.	Tarsus.	Bill.
1 ♂	.. ..	89	81	21.5	23

*Colour of bare parts.*—Iris dark brown. Bill waxy dark brown. Legs, feet and claws slaty. Pads dirty fleshy white.

*Field notes.*—A few seen singly in forest around Pachmarhi. The testes of the ♂ (Feb. 14th) measured  $1.5 \times 1.5$  mm.

Osmaston (1922, p. 454) says it is common in Pachmarhi where it is specially noticeable from May to June.

In western Central India, Ali and Whistler (1939, p. 88) found it at several places; they noted that the April specimens had testes enlarged up to  $5 \times 4$  mm., while August ones were undergoing the post-nuptial moult.

## Family PYCNONOTIDAE.

**Molpastes cafer pallidus** Stuart Baker.

(The Central Indian Red-vented Bulbul.)

*Specimen obtained—*

Singanama.—1♀, 19.2.41.

Elsewhere noted at: Pachmarhi.

*Measurements* (mm.)—

		Wing.	Tail.	Tarsus.	Bill.
1 ♀	.. ..	91.5	84	22	18

*Colour of bare parts.*—Iris dark brown. Bill black. Legs, feet and claws horny black. Pads dirty white.

*Field notes.*—Common in the scrub jungle north-west of Pachmarhi, but rare in the station itself. Common at Singanama.

The ovary of the ♀ (Feb. 19th) measured  $4 \times 3$  mm.

Osmaston (1922, p. 454) says it is very common in Pachmarhi but rare in the surrounding jungles, which is contrary to my observations made in the middle of February, 1941. He further says it breeds in gardens, etc. from May to August.

In western Central India, Ali and Whistler (1939, p. 88) recorded it as common.

## Family TURDIDAE.

***Saxicola caprata ?bicolor* Sykes.**

(The Northern Indian Stone-chat.)

*Specimens obtained—*

Around Pachmarhi.—1(♂), 12.2.41 ; 1(♀), 14.2.41.

*Measurements (mm.)—*

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	66	49	21	11
1 ♀	..	..	70	49	22	15

*Colour of bare parts.*—♂ : Bill black. Legs and feet horny. Claws horny black. Pads dirty horny brown. ♀ : Iris dark brown. Bill dark brownish black. Legs, feet and claws horny black. Pads dusky.

*Field notes.*—A few seen singly at Pachmarhi.

Osmaston (1922, p. 456) says it is common on the Pachmarhi Plateau.

In western Central India, Ali and Whistler (1939, p. 89) recorded it as uncommon.

***Saxicola torquata indica* (Blyth).**

(The Indian Bush-chat.)

*Specimens obtained—*

Singanama.—1♂, 18.2.41.

Itarsi.—1(♂), 24.2.41.

*Measurements (mm.)—*

			Wing.	Tail.	Tarsus.	Bill.
2 ♂♂	..	..	66-67	52-54	20-22	13-14

*Colour of bare parts.*—Iris brown. Bill black. Legs, feet and claws black. Pads smoky.

*Field notes.*—A few seen singly at Singanama and Itarsi on low trees and bushes ; uncommon.

The testes of the Singanama male (Feb. 18th) were in the non-breeding condition and measured 1×1 mm.

Osmaston (1922, p. 456) says it is a winter visitor to Pachmarhi.

In western Central India, Ali and Whistler (1939, p. 89) recorded it as fairly common—earliest date 17th September, latest 17th April.

***Phoenicurus ochruros rufiventris* (Vieillot).**

(The Eastern Indian Redstart.)

*Specimen obtained—*

Singanama.—1(♂), 18.2.41.

*Measurements (mm.)—*

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	88	65	25.5	17

*Colour of bare parts.*—Iris dark chocolate brown. Bill horny brown. Legs, feet and claws horny brown. Pads dirty white.

*Field notes.*—One or two seen at Singanama.

Osmaston (1922, p. 456) says it is a common winter visitor to Pachmarhi.

In western Central India, Ali and Whistler (1939, p. 89) noted it at several places—last date of departure April 16th, by which most had departed; earliest date of arrival September 10th, becoming appreciably commoner by September 19th.

*Systematic note.*—I have followed Whistler and Kinnear<sup>1</sup> in determining the subspecies. The black feathers show a few dark grey edgings, but, with the large wing, the specimen would appear to be *rufiventris*.

### **Copsychus saularis saularis** (Linnaeus).

(The Indian Magpie-Robin.)

*Specimen obtained*—

Pachmarhi. 1♀, 14.2.41.

*Measurements* (mm.)

			Wing.	Tail.	Tarsus.	Bill.
1 ♀	..	..	90	78	28	22

*Colour of bare parts.* Bill horny black. Legs and feet horny. Claws black. Pads waxy pale yellow.

*Local name.* " Kāli sooi chiriā. "

*Field notes.*—Fairly common at Pachmarhi.

The ovary of the ♀ was in the non-breeding condition and measured about 4×4 mm.

Osmaston (1922, p. 456) says it is very common in and around Pachmarhi.

In western Central India, Ali and Whistler (1939, p. 89) found it common in song towards the end of February and in March, and moulting the rectrices in September.

### **Monticola solitaria pandoo** (Sykes).

(The Indian Blue Rock-Thrush.)

*Specimens obtained*—

Pachmarhi.—1♂, 16.2.41.

Harda.—1♂, 1.3.41; 1♀, 3.3.41.

NOTE.—The ♀ here recorded is sooty brown with a faint bluish tinge.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
2 ♂♂	..	..	125-127	93-95	28-30	25.5-28
1 ♀	..	..	117	84	29	28

<sup>1</sup> Whistler, H. and Kinnear, N. B., *Journ. Bombay Nat. Hist. Soc.* XXXVI, p. 70 (1932).

*Colour of bare parts.*—♂ : Iris dark brown. Bill dark horny brown. Legs, feet and claws black. Pads dirty white. ♀ : Iris dark brown. Bill dark smoky brown. Legs, feet and claws dark smoky brown. Pads dirty white.

*Field notes.*—Uncommon at Pachmarhi and Harda.

The testes of the Pachmarhi (Feb. 16th) and Harda (Mar. 1st) specimens were in the non-breeding condition, measuring about  $2 \times 1$  mm. The ovary of the Harda ♀ (Mar. 3rd) was also in the non-breeding condition and measured  $6 \times 4$  mm.

Osmaston (1922, p. 456) says it is occasionally seen in winter at Pachmarhi.

In western Central India, Ali and Whistler (1939, p. 90) found it not uncommon—latest date April 4th, earliest September 11th.

### ***Myiophonus coeruleus horsfieldii* Vigors.**

(The Malabar Whistling Thrush.)

*Specimen obtained*—

Around Pachmarhi.—1 (sex ?), 13.2.41.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 (sex?) .. ..	152	(110)	43	30

*Colour of bare parts.*—Iris dirty olive green (not brown). Bill black. Legs, feet and claws horny black. Pads dirty white.

*Local name.*—“ Bhangraj. ”

*Field notes.*—Three or four solitary specimens were seen near streams and shady gorges around Pachmarhi. The call consists of a most melodious drawn-out whistle uttered as the bird shoots along the gorges. Not seen elsewhere.

Osmaston (1922) says it is common at Pachmarhi and breeds from 15th June.

Ali and Whistler (1939) did not come across it in western Central India.

### Family MUSCICAPIDAE.

### ***Culicicapa ceylonensis ceylonensis* (Swainson).**

(The Grey-headed Flycatcher.)

*Specimen obtained*—

Forest around Pachmarhi.—1 (sex?), 16.2.41.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 (sex?) .. ..	62	59	14	13

*Field notes.*—Fairly common in the forests around Pachmarhi.

Osmaston (1922, p. 455) says it is common at Pachmarhi in ravines and by streams, and breeds in June-July.

In western Central India, Ali and Whistler (1939, p. 92) recorded "*C. c. pallidor*" which they found uncommon.

As I have shown earlier<sup>1</sup>, I am unable to separate *pallidor* Ticehurst from the typical *ceylonensis*.

**Leucocirca aureola aureola** (Lesson).

(The White-browed Fantail-Flycatcher.)

*Specimen obtained*—

Pachmarhi.—1♀, 14.2.41.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
1 ♀	..	..	80	89	18	14

*Colour of bare parts.*—Iris dark chocolate brown. Bill black. Legs, feet and claws horny black. Pads dirty white.

*Field notes.*—Saw a flock of about 10 on the golf links at Pachmarhi.

Osmaston (1922, p. 453) says it is fairly common at Pachmarhi in the cold weather but does not breed there.

In western Central India, Ali and Whistler (1939, p. 92) found it common.

Family LANIIDAE.

**Lanius schach perythronotus** (Vigors).

(The Rufous-backed Shrike.)

*Specimens obtained*—

Singanama.—1♂, 18.2.41.

Pipariya.—2♂♂, 23.2.41.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
3 ♂♂	..	..	86.5-90	109-116	30	17-21.5

*Colour of bare parts.*—Iris dark brown or chocolate brown. Bill black—in one ♂ the lower bill pale fleshy horny. Legs, feet and claws dull horny grey to black. Pads dirty white.

*Field notes.*—Two or three seen at Singanama near cultivated fields. Fairly common at Pipariya where several were seen sitting singly on hedges near cultivated fields.

The testes of the three males (Feb. 18th-23rd) were small and measured  $2 \times 1$  mm.

Osmaston (1922, p. 455) says it is not common on the Pachmarhi Plateau but is seen there occasionally in winter.

<sup>1</sup> Roonwal, M. L., *Rec. Ind. Mus.* XLI, p. 292 (1939).

North of the Hoshangabad District, Ali and Whistler (1939, p. 93) found it in western Central India, where some were seen carrying nest material on August 25th.

*Systematic note.*—I have followed Whistler and Kinnear<sup>1</sup> who have cleared up the question of the races of this shrike. In the skins from the Hoshangabad District the rufous extends to all the scapulars. I consider these skins *erythronotus*. The wings are much smaller (86.5-90 mm.) than the measurements given by Whistler and Kinnear.

### Family CAMPEPHAGIDAE.

#### **Pericrocotus peregrinus peregrinus** (Linnaeus).

(The Small Minivet.)

#### *Specimens obtained*—

Around Pachmarhi.—1♂, 9.2.41; 1♂ (first winter), 11.2.41; 1♂, 12.2.41.

#### *Measurements* (mm.)—

		Wing.	Tail.	Tarsus.	Bill.
2 ad. ♂♂	..	69-70	78.5-80.5	17-18	12.5-14.5
1 imm. ♂	..	68	78	16.5	..

*Colour of bare parts.*—Adult ♂: Iris dark brown. Bill black. Legs, feet and claws horny black. Pads pale horny. First winter ♂: Upper bill horny black; lower bill dull fleshy plumbeous at base and darker at tip. Rest as in adult ♂.

*Field notes.*—Common at Pachmarhi. The testes of one of the males (Feb. 12th) were small, measuring 1×1 mm.

Osmaston (1922, p. 455) says it is very common on the Pachmarhi Plateau and breeds in April and May.

In western Central India, Ali and Whistler (1939, p. 94) found it common; family parties were noted in August-September.

*Systematic note.*—Following the able exposition of the races by Whistler and Kinnear<sup>2</sup>, I have rejected the confusing account of this minivet by Stuart Baker<sup>3</sup>, the name *cinnamomeus* has not been accepted.

#### **Graucalus macei macei** Lesson.

(The Large Indian Cuckoo-Shrike.)

#### *Specimens obtained*—

Pachmarhi.—1♂, 13.2.41.

Singanama.—1♂, 20.2.41; 1♀, 20.2.41.

#### *Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
2 ♂♂	..	...	167-175	132-138	25-26	28-29
1 ♀	..	..	160	133	27	28

<sup>1</sup> Whistler, H. and Kinnear, N. B., *Journ. Bombay Nat. Hist. Soc.* XXXVI, p. 336 (1933).

<sup>2</sup> Whistler, H. and Kinnear, N. B., *Journ. Bombay Nat. Hist. Soc.* XXXVI, p. 342 (1933).

<sup>3</sup> Stuart Baker, E. C., *Faun. Brit. Ind., Birds* (2nd ed.) II, p. 329 (1924).

*Colour of bare parts.*—Iris dark brown in male, dark rufous brown in female. Bill, legs, feet and claws black. Pads dirty white.

*Field notes.*—Only one seen at Pachmarhi on the top of a tree. At Singanama also seen on tops of trees. Evidently rare.

The gonads of the three specimens (Feb. 13th and 20th) were in the non-breeding condition, and measured thus: testes about  $2 \times 2$  mm.; ovary  $4 \times 3$  mm.

Osmaston (1922) says it is common at Pachmarhi and breeds in April.

Ali and Whistler (1939, p. 94) recorded it from several places in western Central India.

### Family DICRURIDAE.

#### **Dicrurus macrocercus peninsularis** Ticehurst.

(The Black Drongo.)

##### *Specimens obtained*—

Pipariya.—1♀ (first winter), 23.2.41.

Harda.—1♀, 3.3.41; 1♂ (first winter), 3.3.41.

Elsewhere noted at: Itarsi.

##### *Measurements (mm.)*—

	Wing.	Tail.	Tarsus.	Bill.
1 ad. ♀ .. ..	140	154	21	23
1 imm. ♀ .. ..	134	138	22	24
1 imm. ♂ .. ..	135	134	24	23

*Colour of bare parts.*—Adult ♀: Iris chocolate brown. Bill glossy black. Legs, feet and claws black. Pads smoky.

*Field notes.*—Common at Pipariya and Harda where they were met with usually singly and sitting on telegraph wires. At Itarsi they were seen in association with grazing cattle, often hopping on to their backs.

*Systematic note.*—I have followed Ticehurst's<sup>1</sup> revision of *D. macrocercus*. Birds from western Central India and from southern Central Provinces are also said to be *peninsularis*.

Osmaston (1922, p. 454) says it was only once seen at Pachmarhi.

In western Central India, just north of the Hoshangabad District, Ali and Whistler (1939, p. 95) recorded *D. m. peninsularis* as common.

#### **Dicrurus caerulescens caerulescens** (Linnaeus).

(The White-bellied Drongo.)

##### *Specimen obtained*—

Around Pachmarhi.—1♂, 10.2.41.

##### *Measurements (mm.)*—

	Wing.	Tail.	Tarsus.	Bill.
1 ♂ .. ..	131	129	20	23

<sup>1</sup> Ticehurst, C. B., *Journ. Bombay Nat. Hist. Soc.* XXXVI, pp. 927-929 (1933),

*Colour of bare parts.*—Bill, legs, feet and claws horny black.

*Field notes.*—Only one or two seen at Pachmarhi.

Osmaston (1922, p. 454) says it is the common King Crow of the Pachmarhi Plateau and breeds in March-April.

In western Central India, Ali and Whistler (1939, p. 95) found it common ; they recorded it as breeding in April.

#### Family ORIOLIDAE.

#### **Oriolus xanthornus maderaspatanus** Franklin.

(The Central Indian Black-headed Oriole.)

*Specimen obtained*—

Pachmarhi.—1 (sex?), 15.2.41.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 (sex?) .. ..	142	95	..	29

*Field notes.*—Fairly common at Pachmarhi ; seen singly on tall trees. Not noted elsewhere.

Osmaston (1922, p. 455) says it is common on the Pachmarhi Plateau and breeds in May.

In western Central India, Ali and Whistler (1939, p. 99) found it rare, having noted it only at Guna in the Gwalior State.

*Systematic note.*—I have followed Whistler and Kinnear's <sup>1</sup> exposition of the races of this bird. The Pachmarhi specimen is *maderaspatanus*.

#### Family FRINGILLIDAE.

#### **Carpodacus erythrinus roseatus** (Blyth).

(The Common Indian Rose-Finch.)

*Specimen obtained*—

Around Pachmarhi.—1 ♂, 15.2.41.

*Measurements* (mm.)

	Wing.	Tail.	Tarsus.	Bill.
1 ♂ .. ..	84	61	19	14

*Colour of bare parts.*—Iris dark brown. Upper bill horny ; lower bill silvery grey. Legs and feet dark horny brown. Claws horny. Pads dirty white.

*Field notes.*—A pair seen on a tree about 2 miles from Pachmarhi.

The testes of the ♂ (Feb. 15th) were small and measured 1×1 mm.

Osmaston (1922) does not include this Rose-Finch in his list of Pachmarhi birds.

<sup>1</sup> Whistler, H. and Kinnear, N. B., *Journ. Bombay Nat. Hist. Soc.* XXXVI, p. 584 (1933).



Ali and Whistler (1939, p. 101) recorded *C. e. erythrinus* as being a common winter visitor (Sept. 15th to April 7th) to western Central India, just north of the Hoshangabad District; they did not find *C. e. roseatus*.

***Gymnoris xanthocollis xanthocollis* (Burton).**

(The Yellow-throated Sparrow.)

*Specimens obtained—*

Around Pachmarhi.—2 ♂♂, 14.2.41; 1 (sex ?), 14.2.41.

Singanama.—1 ♂, 19.2.41.

Pipariya.—1 ♀, 22.2.41; 1 (sex ?), 22.2.41.

Elsewhere noted at: Itarsi.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
3 ♂♂	..	..	79-86	55-61	16.5-19	14-15
1 ♀	..	..	78	56	18	13
2 (sex ?)	..	..	80.5-85	51-56	17-18	13.5-14

*Colour of bare parts.*—♂: Iris olive brown to chocolate brown. Bill waxy dark brown. Legs, feet and claws dull slaty. ♀: Not noted.

*Field notes.*—Extremely common at Pachmarhi, especially near the cultivated fields where they congregate in the mornings in flocks of 30 or more, making a chirping din characteristic of sparrows. Also common at Singanama near cultivated fields, and at Pipariya. At Itarsi they were seen picking grain on meadows in large flocks of over 100 birds.

The gonads of the four birds examined at Pachmarhi and Pipariya were all in the quiescent state. The testes measured about  $1 \times 1$  to  $2 \times 1$  mm.; the ovary (Pipariya, Feb. 22nd),  $4 \times 4$  mm.

Osmaston (1922, p. 456) says it is extremely common at Pachmarhi.

In western Central India, Ali and Whistler (1939, p. 101) found it common in the dry season but absent in August and early September, appearing again in late September; they considered it a "decidedly local migrant".

Family MOTACILLIDAE.

***Motacilla maderaspatensis* J. F. Gmelin.**

(The Large Pied Wagtail.)

*Specimens obtained—*

Itarsi.—1 (sex ?), 24.2.41.

Bank of R. Narbada at Handia.—1 ♂, 27.2.41.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	96	107	29	19
1 (sex ?)	..	..	101	109	29	21

*Colour of bare parts.*—Iris dark brown. Bill black. Legs, feet and claws horny black. Pads smoky white.

*Field notes.*—A few seen near a stream at Itarsi, and on the banks of the Narbada at Handia.

The testes of the Handia ♂ (Feb. 27th) were enlarged and measured  $4 \times 4$  mm., suggesting breeding in March.

Osmaston (1922) does not include this bird in his Pachmarhi list.

In western Central India, Ali and Whistler (1939, p. 103) found it fairly common and evidently breeding in April.

### **Motacilla cinerea caspica** (S. G. Gmelin).

(The Eastern Grey Wagtail.)

*Specimen obtained*—

Pachmarhi (at "Small Waterfall").—1 (sex ?), 16.2.41.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 (sex ?) .. ..	83	96	20	17.5

*Field notes.*—Only one seen at the "Small Waterfall" near Pachmarhi.

Osmaston (1922, p. 456) says it is a common winter visitor to the Pachmarhi Plateau, arriving about 1st September.

In western Central India, Ali and Whistler (1939, p. 103) found it at several Places in winter (earliest date Sept. 5th, latest Apr. 8th); some were in the breeding dress.

### **Anthus hodgsoni hodgsoni** (Richmond).

(The Indian Tree-Pipit.)

*Specimen obtained*—

Around Pachmarhi.—1 ♀, 12.2.41.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 ♀ .. ..	87.5	62	22	14

*Field notes.*—One seen at Pachmarhi.

Osmaston (1922, p. 456) says it is very common at Pachmarhi in winter, leaving that place in April.

Ali and Whistler (1939, p. 104) did not come across it in western Central India.

## Family ALAUDIDAE.

**Ammomanes phoenicura phoenicura** (Franklin).

(The Indian Rufous-tailed Finch-lark.)

*Specimens obtained*—

Singanama.—1 ♂, 20.2.41.

Bank of R. Narbada at Sandia.—1 ♂, 21.2.41 ; 1 ♀, 21.2.41.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
2 ♂♂	..	..	104-109	67-79	24	17
1 ♀	..	..	100	67	23	14

*Colour of bare parts.* Iris dark brown. Upper bill horny ; lower bill pale horny with dark tip. Legs and feet pale rufous. Claws pale horny.

*Field notes.* A pair seen in a stubble field at Singanama. Common singly or in twos and threes on the banks of the Narbada at Sandia, probably coming from the adjoining fields to drink. This habit of frequenting banks of rivers does not appear to have been recorded before.

The gonads of the three specimens (Feb. 20th, 21st) were in the breeding condition. The testes measured about  $5 \times 4$  mm. ; the ovary about  $8 \times 8$  mm., with the largest egg-follicles about  $1 \times 1$  mm.

I did not see it at Pachmarhi, nor does Osmaston (1922) record it from there.

In western Central India, Ali and Whistler (1939, p. 106) found it fairly common in open cultivated country but make no mention of having seen it on river banks ; specimens taken on 16th February had maturing gonads ; they were found in flocks of 50 or more in September.

## Family NECTARINIIDAE.

**Leptocoma asiatica asiatica** (Latham).

(The Indian Purple Sunbird.)

*Specimen obtained*—

Around Pachmarhi.—1 ♂ (metallic plumage), 10.2.41.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	56	37	15	21

*Colour of bare parts.*—Iris dark brown. Bill, legs, feet and claws black.

*Field notes.*—Only one or two seen in the jungle around Pachmarhi.

The testes of the ♂ (Feb. 10th) were moderately enlarged and measured  $1.5 \times 1.5$  mm.

Osmaston (1922, p. 456) says it is common in Pachmarhi and breeds during April to June.

In western Central India, Ali and Whistler (1939, p. 106) found it common ; they record it as breeding in March-April.

## Order CORACIIFORMES.

## Family PICIDAE.

**Dryobates maharattensis** (subsp. ?).

(The Yellow-fronted Pied Woodpecker.)

*Specimen obtained—*

Singanama.—1 (sex ?), 19.2.41.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 (sex ?) .. ..	104	69	20	25

*Colour of bare parts.*—Iris dark red. Bill waxy grey, darker at tip. Legs and feet waxy grey. Claws horny.

*Field notes.*—Only one seen at Singanama, tapping persistently on the bark of a tree.

Osmaston (1922, p. 456) says it is not uncommon on the Pachmarhi Plateau.

In western Central India, Ali and Whistler (1940, p. 470) found it common ; a nest with parents feeding the half-grown chicks was found on April 16th.

## Family CAPITONIDAE.

**Thereiceryx zeylanicus** (subsp. ?).

(The Green Barbet.)

*Specimen obtained—*

Pachmarhi.—1 ♂, 15.2.41.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 ♂ .. ..	120	80	28	31.5

*Colour of bare parts.*—Iris brown. Bill pink. Legs and feet fleshy yellow. Claws horny. Bare skin around the eyes yellowish.

*Local name.*—“Gummā”.

*Field notes.*—Only one seen at Pachmarhi ; evidently rare at this time.

The testes of the ♂ (Feb. 15th) were fairly enlarged and measured  $5 \times 3$  mm.

Osmaston (1922, p. 456) says it is very common at Pachmarhi, and breeds in April-May.

In western Central India, Ali and Whistler (1940, p. 471) found it only at two places in the Bhopal and Gwalior States ; the Bhopal skins were *T. z. caniceps* (Frankl.), while the one from further north, i.e., Gwalior, was intermediate between the subspecies *caniceps* and *kangrae*.

## Family PSITTACIDAE.

**Psittacula cyanocephala cyanocephala** (Linnaeus).

(The Western Blossam-headed Paroquet.)

*Specimens obtained—*

Pachmarhi.—1 (♂), 15.2.41 ; 1 ♀, 15.2.41.

*Measurements (mm.)—*

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	139	(197)	15.5	19
1 ♀	..	..	142	187	14	22.5

*Colour of bare parts.*—♂ : Iris straw yellow. Upper bill pale orange ; lower bill black. Legs, feet and claws mottled horny. Pads dirty white. ♀ : Iris very pale yellow. Upper bill yellow ; lower bill horny. Rest as in ♂.

*Field notes.*—Common at Pachmarhi in flocks of 8 or 10.

The ovary of the ♀ measured  $6 \times 4$  mm. and was evidently in the semi-quiescent stage.

Osmaston (1922, p. 457) says it is common in and around Pachmarhi.

In western Central India, just north of the Hoshangabad District, Ali and Whistler (1940, p. 472) found *P. c. bengalensis* ; these were common and were breeding or about to breed in January.

## Family CORACIIDAE.

**Coracias benghalensis benghalensis** Linnaeus.

(The Indian Roller or Blue Jay.)

*Specimen obtained—*

Pachmarhi.—1 ♂, 14.2.41.

Elsewhere noted at : Pipariya ; Itarsi.

*Measurements (mm.)—*

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	186	129	20.5	41

*Colour of bare parts.*—Iris dark brown. Naked orbital skin pinkish ochreous (not yellow). Bill horny black. Legs and feet dirty yellow. Claws black.

*Local name.*—"Leelkant".

*Field notes.*—Fairly common at Pachmarhi, moving about singly. Common at Pipariya and Itarsi where they were often noticed sitting singly on telegraph wires and trees.

The testes of the ♂ (Feb. 14th) were in the non-breeding condition, and measured about  $3 \times 2$  mm.

Osmaston (1922, p. 457) says it is common on the Pachmarhi Plateau and breeds in April-May.

In western Central India, Ali and Whistler (1940, p. 472) found it sparingly.

## Family MEROPIDAE.

***Merops orientalis orientalis* Latham.**

(The Common Indian Bee-eater.)

*Specimens obtained—*

Around Pachmarhi.—1 ♂, 14.2.41 ; 1 ♀, 14.2.41.

Singanama.—1 ♂, 20.2.41.

*Measurements (mm.)—*

			Wing.	Tail.	Tarsus.	Bill.
2 ♂♂	..	..	90-97	115-129	9.5-11.5	33.5-35
1 ♀	..	..	94	120	12	34

*Colour of bare parts.*—Iris : Crimson with an outer white ring in ♂; bright crimson in ♀. Bill black. Legs and feet fleshy horny. Claws horny. Pads dirty white.

*Local name.*—" Hari sooi chiriā ".

*Field notes.*—Common at Pachmarhi ; found singly or in small flocks of 10 or 15 on trees. Very common at Singanama.

The gonads of the specimens collected were small. The testes of two Pachmarhi and Singanama males (Feb. 14th-20th) measured 1×1 mm. ; the ovary of a Pachmarhi ♀ (Feb. 14th) measured 4×3 mm.

Osmaston (1922, p. 457) curiously, and I think due to oversight, does not include the Common Indian Bee-eater in his earlier Pachmarhi list, although I found it common enough. In a subsequent Pachmarhi list (1936, p. 66), however, he says it is very common.

In western Central India, Ali and Whistler (1940, p. 473) found it " not uncommon, but curiously sparse and local ". In the last week of March they met with individuals with granular ovaries and also individuals digging nests.

## Family ALCEDINIDAE.

***Ceryle rudis leucomelanura* Reichenbach.**

(The North Indian Pied Kingfisher.)

*Specimens obtained—*

Harda.—1 ♂, 1.3.41 ; 1 ♀, 1.3.41 ; 1 ♀, 4.3.41.

*Measurements (mm.)—*

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	142	80	12	66
2 ♀♀	..	..	140-143	75-88	12	61-62

*Colour of bare parts.*—Iris very dark brown. Bill horny black. Legs, feet and claws smoky horny to black. Pads smoky white.

*Field notes.*—Common at Harda on banks of streams. Not noted elsewhere.

The three specimens shot at Harda (Mar. 1st-4th) were evidently breeding, as the gonads were greatly enlarged. The testes measured  $8 \times 5$  mm. The ovaries measured  $8 \times 7$  to  $16 \times 9$  mm. and showed fairly large egg-follicles.

Osmaston (1922, p. 457) says it is occasionally seen around the lake at Pachmarhi.

In western Central India, Ali and Whistler (1940, p. 473) recorded a bird with ripe testes on Jan. 15th, and a nest on Feb. 4th; the ovaries of a ♀ on Sept. 7th were granular.

***Alcedo atthis taprobana* Kleinschmidt.**

(The Common Ceylon Kingfisher.)

*Specimen obtained*—

Harda.—1 ♂, 2.3.41.

*Measurements* (mm.)—

	Wing.	Bill.
1 ♂ .. ..	69	44

*Colour of bare parts*.—Iris dark brown. Bill black. Legs, feet and pads reddish orange. Claws horny orange at base, horny at tip.

Testes of the ♂ shot on Mar. 2nd were moderately large, measuring  $2.5 \times 2$  mm., evidently indicating breeding in the near future.

*Field notes*.—Seen occasionally at Harda near streams, but not common.

Osmaston (1922, p. 457) says it is not uncommon in and around Pachmarhi, and is a resident bird; the breeding season, however, is not stated.

In western Central India, Ali and Whistler (1940, p. 473) recorded mostly *A. a. bengalensis*, but also one specimen of *A. a. taprobana*.

***Halcyon smyrnensis ?smyrnensis* (Linnaeus).**

(The North Indian White-breasted Kingfisher.)

*Specimens obtained*—

Singanama.—1 ♂, 22.2.41.

Harda.—1 ♂, 3.3.41.

Elsewhere noted at: Pachmarhi.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
2 ♂♂ .. ..	122-123	94-95	16	62-64

*Colour of bare parts*.—Iris dark chocolate brown. Bill deep red. Legs and feet deep red to deep reddish orange, with smoky tinge in front. Foot pads reddish orange. Claws smoky horny.

*Field notes*.—One specimen seen at Pachmarhi on Feb. 14th; evidently rare at this time of the year. Fairly common at Singanama near streams. Not common at Harda where only a few were seen near streams.

The testes of both the males (Feb. 22nd and Mar. 3rd) were in the non-breeding condition, measuring about  $2 \times 1$  mm.

Osmaston (1922, p. 457) says it is common on the Pachmarhi Plateau and breeds in April-May.

*Systematic note.*—Whistler and Kinnear<sup>1</sup> have shown that there is an indication of a larger North Indian race (*smymensis*) and a smaller South Indian race (*fusca*) of this kingfisher. By their size, the Hoshangabad District specimens would seem to belong to the typical race.

## Family BUCEROTIDAE.

### *Tockus birostris* (Scopoli).

(The Common Grey Hornbill.)

#### *Specimens obtained*—

Pachmarhi.—1 ♀, 10.2.41.

Singanama.—1 ♂, 19.2.41.

Elsewhere noted at : Pipariya.

#### *Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	216	297	50	116
1 ♀	..	..	205	288	(46)	90

*Colour of bare parts.* —♂ : Iris deep red-orange. Casque and base of bill black ; rest of bill waxy white. Legs, feet and claws horny. Pads dirty white. Bare area around eye black. ♀ : Iris with an outer ring of white merging into an inner brown ring. Rest as in ♂.

*Field notes.*—At Pachmarhi this bird was encountered on Feb. 10th in the forest close to the Chemical Warfare School, flying either singly or in groups of 8 or 10 on the tops of tall trees. Also seen a single specimen on Feb. 14th two miles north of Pachmarhi on the road to Pipariya. Common at Singanama, visiting the *Ficus* ("bar") trees close to the Rest House in the mornings between about 7 and 9 A.M., usually in pairs ; also common in the forests at Singanama towards R. Denwa. A few also seen at Pipariya on Feb. 22nd.

The call is a sharp, slightly hoarse and drawn out *Peen-n-n-n*, *Peen-n-n-n*, each lasting for about 5 seconds, with longer intervals between two successive *Peen-n-n-n*'s. It strongly recalls the call of the Common Pariah Kite.

The testes of the ♂ shot at Singanama on Feb. 19th were in the non-breeding condition and measured  $4 \times 3$  mm.

Osmaston (1922, p. 457) says it is very common on the Pachmarhi Plateau, especially in the spring.

In western Central India, Ali and Whistler (1940, p. 473) found it common.

<sup>1</sup> Whistler, H. and Kinnear, N. B., *Journ., Bombay, Nat. Hist. Soc.* XXXVII, pp. 761, 762 (1935).



## Family UPUPIDAE.

**Upupa epos ceylonensis** Reichenbach.

(The Ceylon Hoopoe.)

*Specimens obtained*—

Pachmarhi.—1 ♂, 12.2.41 ; 1 ♂, 13.2.41.

*Measurements* (mm.)—

		Wing.	Tail.	Tarsus.	Bill.
2 ♂♂	.. ..	135-139	98-105	21-23	56-57

*Colour of bare parts*.—Iris dark brown.*Local name*.—"Khatōlā".*Field notes*.—Tolerably common at Pachmarhi, moving about singly. Not seen elsewhere.The testes (12th-13th Feb.) were large and measured  $3 \times 2$  to  $5 \times 4$  mm., indicating breeding.

Osmaston (1922, p. 457) says it is common on the Pachmarhi Plateau and breeds in April.

In western Central India, Ali and Whistler (1940, p. 474) came across specimens of both *U. e. epops* and *U. e. ceylonensis*; some of these were evidently breeding in February and April.

## Family ASTONIDAE.

**Athene brama indica** (Franklin).

(The Northern Spotted Owlet.)

*Specimen obtained*—

Pipariya.—1 ♂, 23.2.41.

*Measurements* (mm.)—

		Wing.	Tail.	Tarsus.	Bill.
1 ♂	.. ..	147	79	32	21

*Colour of bare parts*.—Iris lemon yellow. Bill greyish yellow. Feet and pads light buff. Claws horny.*Field notes*.—Only one seen during the day on the top of a tamarind tree.The testes (Feb. 23rd) were moderately enlarged and measured  $4 \times 3$  mm., suggesting breeding in the near future.

Osmaston (1922, p. 458) says it occurs at Pachmarhi but is not common.

In western Central India, Ali and Whistler (1940, p. 475) found a bird with granular ovaries at Chanderi in the Gwalior State on April 8th.

**Glaucidium radiatum radiatum** (Tickell).

(The Jungle Owlet.)

*Specimens obtained—*

Forest around Pachmarhi.—1 ♂, 9.2.41.

Singanama.—1 ♂, 18.2.41 ; 1 ♀, 19.2.41.

*Measurements (mm.)—*

			Wing.	Tail.	Tarsus.	Bill.
2 ♂♂	..	..	130-132	78-80	27-28	19
1 ♀	..	..	136	84	(26)	..

*Colour of bare parts.*—Iris bright yellow in ♂, lemon yellow in ♀. Bill ashy yellow. Feet and pads ashy ochreous. Claws horny with black tips.

*Field notes.*—One seen in the jungle near Pachmarhi, and two at Singanama. The testes of the ♂ (Feb. 18th) measured  $3 \times 2$  mm. ; the ovaries of the ♀ (Feb. 19th) measured  $7 \times 5$  mm.

Osmaston (1922, p. 458) says the bird is common in the Pachmarhi forests and breeds in April-May.

Ali and Whistler (1940, p. 475) did not come across it in western Central India.

## Order ACCIPETRES.

## Family AEGYPIIDAE.

**Pseudogyps bengalensis** (J. F. Gmelin).

(The Indian White-backed Vulture.)

*Specimen obtained—*

Pachmarhi.—1 ♂, 12.2.41.

*Measurements (mm.)—*

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	(580)	214	(98)	62

*Field notes.*—Fairly common at Pachmarhi, being often seen in groups of 10 or 12 near carcasses on rocks. Often seen in company with the Neophron.

The testes of the ♂ (Feb. 12th) were in the quiescent stage, and measured  $2.5 \times 2$  mm.

Osmaston (1922, p. 458) says it occurs on the Pachmarhi Plateau but does not breed there.

In western Central India, Ali and Whistler (1940, p. 476) found it common everywhere.

**Neophron percnopterus ginginianus** (Latham).

(The Neophron or Smaller White Scavenger Vulture.)

*Specimen obtained*---

Singanama.—1 (sex ?) (first winter ?), 19.2.41.

Elsewhere noted at : Pachmarhi ; Itarsi.

NOTE.—The Singanama bird was acquiring the white adult plumage, but the brown patches were still evident in several places.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 (sex ?) .. ..	465	234	83	62.5

*Colour of bare parts*.—Iris white, with inner purple ring. (Stuart Baker, 1928, p. 23, does not give the colour of the iris ; for the typical race he gives the colour as yellow or dark brown.) Bill fleshy grey (in immature bird). Bare skin on head and chin yellow. Legs and feet pinkish white. Claws dark horny.

*Field notes*.—Several specimens, both pure white (adults) and brown ones (immature first winter birds) were noted in small numbers at Pachmarhi on Feb. 12th and subsequently in company with the Indian White-backed Vulture, *Pseudogyps bengalensis*. All adults were yellow-beaked and, therefore, *ginginianus*. A solitary bird noted at Singanama (specimen collected). Also noted in fair numbers at Itarsi on Feb. 24th.

Osmaston (1922, p. 458) says it is common at Pachmarhi where it breeds on the cliffs ; the breeding season, however, is not stated.

In western Central India, Ali and Whistler (1940, p. 476) noted two nests with brooding birds at Surwaya in the Gwalior State on the 22nd March.

## Family FALCONIDAE.

**Milvus migrans govinda** Sykes.

(The Common Pariah Kite.)

*Specimen obtained*---

Pachmarhi.—1 ♀, 11.2.41.

Elsewhere noted at : All the places visited in the District.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 ♀ .. ..	487	320	59	39.5

*Colour of bare parts*.—Bill horny. Legs and feet waxy grey-white. Pads dirty waxy-white. Claws horny.

*Field notes*.—Common at all the places visited in the Hoshangabad District.

Osmaston (1922, p. 458) also found it common at Pachmarhi. No indication of the breeding season in the District is available.

In western Central India, Ali and Whistler (1940, p. 477) found it common, especially in and about towns.

## Order COLUMBAE.

## Family COLUMBIDAE.

***Streptopelia orientalis meena* (Sykes).**

(The North Indian Rufous Turtle-Dove.)

*Specimen obtained—*

Singanama.—1 ♂, 18.2.41.

*Measurements (mm.)—*

		Wing.	Tail.	Tarsus.	Bill.
1 ♂	.. ..	200	136	25	23

*Colour of bare parts.*—Bill fleshy horny. Legs and feet dark horny. Claws waxy horny. Pads pinkish white. Naked orbital skin grey beneath eye, dark pink elsewhere.

*Field notes.*—Only one or two seen at Singanama ; evidently rare.

The testes of the ♂ were small and measured  $3 \times 2$  mm.

Osmaston (1922, p. 459) says it occurs in Pachmarhi throughout the year but is most common in winter.

Ali and Whistler (1940, p. 477) recorded a few specimens from the Gwalior and Bhopal States in western Central India.

*Systematic note.*—This bird is the *meena* Sykes of Whistler and Kinnear<sup>1</sup>, i.e., the bird which breeds in the N. W. Himalayas ; it is not the *meena* Sykes of Stuart Baker<sup>2</sup>. (Also see Roonwal<sup>3</sup>, 1941, p. 328)

***Streptopelia chinensis suratensis* (J. F. Gmelin).**

(The Indian Spotted Dove.)

*Specimen obtained—*

Around Pachmarhi. ---1 ♀, 11.2.41.

Elsewhere noted at : Singanama.

*Measurements (mm.)—*

		Wing.	Tail.	Tarsus.	Bill.
1 ♀	.. ..	143	141	22	22

*Local name.*—"Pharki"—probably a general name for all doves.

*Field notes.*—Very common at Pachmarhi in thin forest on rocks and plains ; usually found singly. Extremely common at Singanama. None seen at Itarsi where it appeared to be absent, although other doves were seen.

<sup>1</sup> Whistler, H. and Kinnear, N. B., *Journ., Bombay, Nat. Hist. Soc.* XXXVIII, pp. 677-679 (1936).

<sup>2</sup> Stuart Baker E. C., *Faun. Brit. Ind., Birds* (2nd ed.) V, p. 240 (1928).

<sup>3</sup> Roonwal, M. L. *Rec. Ind. Mus.* XLIII, pp. 328-332 (1941).

Osmaston (1922, p. 459) says it is common in and around Pachmarhi.

In western Central India, Ali and Whistler (1940, p. 477) found it common ; a nest with eggs was met with on September 19th.

***Streptopelia senegalensis cambayensis* (J. F. Gmelin).**

(The Indian Laughing Dove or Little Brown Dove.)

*Specimen obtained*—

Itarsi.—1 ♂, 24.2.41.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	122	115	19	18

*Colour of bare parts*.—Naked orbital skin grey. Bill and cere horny black. Legs and feet purple. Claws horny black. Pads dirty grey-brown.

*Field notes*.—Common at Itarsi in meadows and thin forest. Not noted elsewhere.

The testes of the ♂ (Feb. 24th) were small and measured  $3 \times 2$  mm.

Osmaston (1922) does not list it as a Pachmarhi bird.

Ali and Whistler (1940, p. 478) found it common in western Central India.

***Streptopelia decaocto decaocto* (Frivaldszky).**

(The Indian Ring-Dove.)

*Specimen obtained*—

Itarsi.—1 ♂, 24.2.41.

Elsewhere noted at : Harda.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	179	146	24	22

*Colour of bare parts*.—Naked orbital skin grey. Bill and cere horny black. Legs and feet purple. Claws horny black. Pads dirty pale brown.

*Field notes*.—Common at Itarsi where it was met with on trees in open grassland. A few seen at Harda.

The testes of the Itarsi ♂ (Feb. 24th) were small, and measured  $2 \times 2$  mm.

Osmaston (1922) does not record it as a Pachmarhi bird.

In western Central India, Ali and Whistler (1940, p. 478) found it common, and obtained nests with eggs on September 18th.

## Order GALLINAE.

## Family PHASIANIDAE.

***Galloperdix lunulata* (Valenciennes).**

(The Painted Spur-Fowl.)

*Specimen obtained—*

Forest around Pachmarhi.—1 ♂ (labelled ♀ in the field, evidently by mistake ; has ♂ plumage), 10.2.41.

NOTE.—The specimen was purchased at Pachmarhi from a local *shikari* who said he got it from the jungles near Pachmarhi.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
1 ♂	..	..	159	132	38	23

*Field notes.*—The specimen is in moulting and new feathers are seen developing on the rump ; the tail shows only 8 feathers. Both the tarsi have two spurs each.

Osmaston (1922, p. 459) says it is common at Pachmarhi on rocky slopes.

In western Central India, Ali and Whistler (1940, p. 478) found it at several places ; specimens taken in March and April had maturing gonads.

## Order CHARADRIIFORMES.

## Family CHARADRIIDAE.

***Lobivanellus indicus indicus* (Boddaert).**

(The Indian Red-Wattled Lapwing.)

*Specimens obtained—*

Itarsi.—1 ♀, 27.2.41.

Bank of R. Narbada at Handia.—1 ♀, 27.2.41.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
2 ♀♀	..	..	210-227	111-131	73-74	36-37

*Colour of bare parts.*—Iris red with a narrow pink outer ring. Bill with tip smoky, rest deep pink. Wattle near eye deep pink. Tibia, tarsus and feet dirty yellow. Claws smoky. Pads pale smoky.

*Field notes.*—Common at Itarsi near streams where they were seen in association with grazing cows. Exhibited a semi-gregarious tendency. Also very common on the banks of the Narbada at Handia.

The ovary of the Itarsi specimen (Feb. 25th) was enlarged, measuring 12×9 mm. ; some of the egg-follicles measured 1.5×1.5 mm. The Handia specimen (Feb. 27th) had a smaller ovary, 5×5 mm.

In western Central India, Ali and Whistler (1940, p. 484) found it common.

## Family SCOLOPACIDAE.

**Tringa hypoleucos** Linnaeus.

(The Common Sandpiper.)

*Specimen obtained*—

Bank of R. Narbada at Sandia.—1 ♂, 21.2.41.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 ♂      ..      ..	107	62	23	30

*Colour of bare parts.*—Iris dark brown. Upper bill fleshy smoky, darker at tip; lower bill fleshy, smoky at tip.

*Field notes.*—A few seen on the bank of the Narbada at Sandia.

In western Central India, Ali and Whistler (1940, p. 485) found it common, the last date being April 19th.

## Order HERODIONES.

## Family PLEGADIDAE.

**Thereskiornis melanocephala** (Latham).

(The White Ibis.)

*Specimen obtained* .

R. Narbada at Handia. 1 ♂ (juv.), 27.2.41.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 ♂ (juv.)      ..	322	123	92	141

*Colour of bare parts.*—Iris brown.

*Field notes.*—A few, perhaps 8 or 10, seen on the Narbada at Handia in small parties of 2 to 4.

The testes of the juv. ♂ (Feb. 27th) measured  $6 \times 4$  mm.

In western Central India, Ali and Whistler (1940, p. 486) found it in small parties in the Bhopal State and the Gwalior State.

## Family ARDEIDAE.

**Egretta garzetta garzetta** (Linnaeus).

(The Little Egret.)

*Specimen obtained*—

R. Narbada at Handia.—1 ♀ (breeding plumage), 27.2.41.

*Measurements* (mm.)—

	Wing.	Tail.	Tarsus.	Bill.
1 ♀      ..      ..	260	99	92	82

*Colour of bare parts.*—Iris brown.

*Field notes.*—Fairly common on the Narbada at Handia, going about singly or in pairs.

The ovary of the ♀ was fairly enlarged and measured  $11 \times 6$  mm., suggesting breeding in the near future.

In western Central India, Ali and Whistler (1940, p. 487) noted it in the Bhopal State and the Gwalior State.

### ***Ardeola grayii* (Sykes).**

(The Indian Pond Heron or Paddy Bird.)

*Specimen obtained* —

R. Narbada at Handia.—1 ♀ (non-breeding plumage), 27.2.41.

*Measurements* (mm.)—

			Wing.	Tail.	Tarsus.	Bill.
1 ♀	..	..	202	77	59	71

*Colour of bare parts.*—Iris yellow-brown.

*Field notes.*—Fairly common on the Narbada at Handia. The ovaries were small and measured  $4 \times 3$  mm.

Osmaston (1922, p. 459) says it is fairly common by the lake at Pachmarhi.

In western Central India, Ali and Whistler (1940, p. 487) found nesting birds in Sangi Tank near Mandleshwar in the Indore State on September 5th.





# RECORDS

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## CYCLOPIDES (CRUSTACÉS COPÉPODES) DE L'INDE, XIV-XVIII.

PAR KNUT LINDBERG.

### XIV. NOTES SUR QUELQUES MEMBRES DU SOUS-GENRE *Metacyclops* KIEFER.

#### **Cyclops (Metacyclops) minutus** Claus.

Une femelle adulte récoltée dans une mare à l'eau saumâtre, à surface couverte d'algues vertes, à Mansouriyéh (village à 6 km. de Béhéhan) présentait une branche de la furca portant une soie apicale supplémentaire à côté et en dedans de la soie apicale externe. Sa longueur en était légèrement inférieure et elle semblait dépourvue de cils. Je donne une figure de la furca montrant cette anomalie curieuse, dont je n'ai pas vu d'autre exemple.

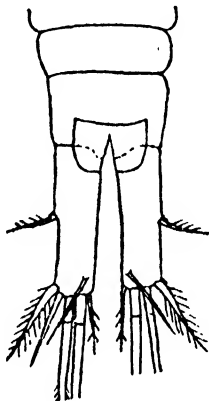


FIG. 1.—*Cyclops (Metacyclops) minutus* Claus ♀.  
Furca, face dorsale (Mansouriyéh).

Il convient de rappeler que dans cette même mare j'ai simultanément pêché un *E. (T.) prasinus* (Fischer) tératologique. Il m'a semblé que des conditions de milieu défavorables peuvent amener une tendance aux anomalies de développement chez certains Cyclopidés.

#### **Cyclops (Metacyclops) planus** Gurney.

Un examen répété d'échantillons récoltés en 1939-40 a révélé des spécimens de *C. (M.) planus* dans quelques tubes où je n'avais d'abord pas remarqué leur présence. Comme cette espèce est encore peu connue je donne ci-dessous quelques mensurations supplémentaires à celles publiées en 1940. On voit ainsi que le rapport entre la longueur et la largeur des branches de la furca va jusqu'à 5 : 1 chez la femelle et atteint 4.50 : 1 chez le mâle, et aussi que l'épine apicale de l'cnp. 4 surpasse parfois chez la femelle la longueur de l'article qui la porte.

**Cyclops (Apocyclops) dengizicus** Lepechkin.

Dans une mare à l'eau saumâtre près du bord de la mer à Guénavéh (port situé à 17 km. au nord de Bender Rig) j'ai récolté un mâle unique que j'ai cru devoir identifier comme un *C. (A.) dengizicus* tératologique. Il présentait une branche gauche de la furca plus longue que la droite et des soies apicales de longueurs un peu inégales, la soie apicale interne de la branche gauche étant notamment plus longue que celle de la branche droite. L'article 2 de l'enp. 4 avait à droite une structure en partie normale puisqu'il portait une soie apicale interne et une épine apicale externe, mais son rebord interne était pourvu de 4 soies au lieu de 3. A gauche la soie apicale, contiguë à l'épine apicale, faisait défaut, et il n'y avait qu'une épine apicale insérée entre deux petits prolongements épineux de l'extrémité de l'article. En dedans du prolongement épineux interne se trouvait une soie située au même niveau que l'épine apicale ; le rebord interne portait 3 soies. La cinquième patte avait une structure ordinaire, mais l'épine interne de la sixième patte rudimentaire était de longueur insolite, atteignant, lorsqu'elle était ramenée sur l'abdomen, le bord postérieur du deuxième segment abdominal.

Dans une mare de caractère semblable à celle de Guénavéh, à Abd Imam (village situé à environ 1 km. au nord de Guénavéh), j'ai récolté

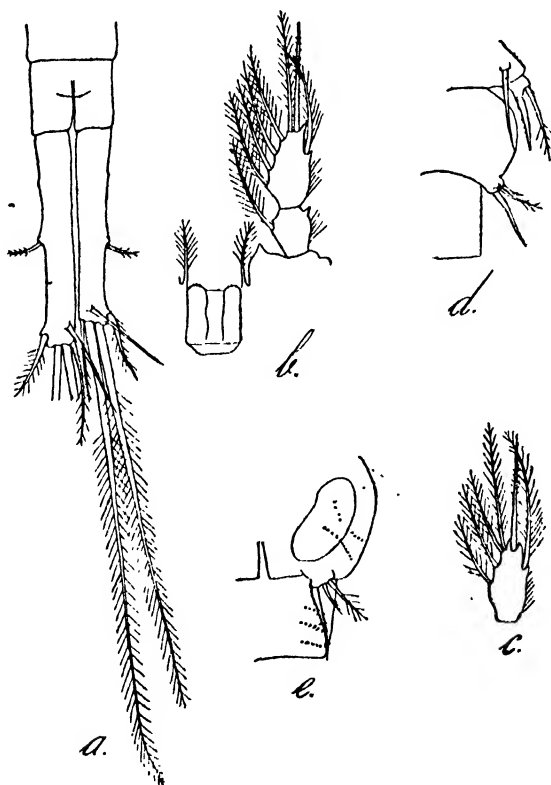


FIG. 2.—*Cyclops (Apocyclops) dengizicus* Lepechkin ♂. (Guénavéh).

a. Furca, face dorsale ; b. Enp. 4, côté droit, face ventrale ; c. Article 2 enp. 4, côté gauche, face dorsale ; d. P 5 et P 6, face latérale ; e. P 6, face ventrale.

un autre mâle unique dont la configuration de la cinquième patte était également pareille à celle de *C. (A.) dengizicus*, et dont l'article 2 de l'enp. 4 portait une soie apicale interne et une épine apicale externe plus longue que l'article. La furca avait cependant une apparence anormale ayant les branches relativement courtes et divergentes, très différentes de celles présentées ordinairement par le mâle du *C. (A.) dengizicus*, tel que je le connais de l'Inde et de l'Iran. Comme je n'ai trouvé aucune femelle et qu'il peut encore dans ce cas-ci s'agir d'un fait tératologique, je crois qu'il serait trop osé de distinguer ce spécimen par un nom nouveau et je le présente provisoirement comme un *C. (A.) dengizicus* anormal. Des mensurations des deux individus sont données ci-dessous.

Les animaux ayant l'article de la cinquième patte fortement élargi, portant une épine interne bien développée et une longue soie externe,

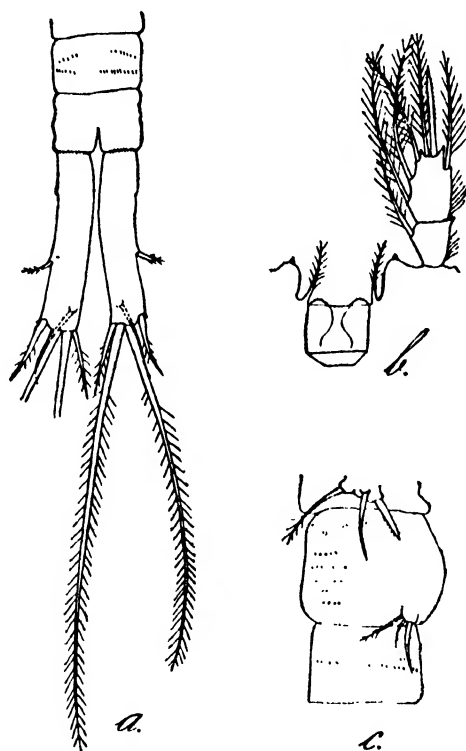


FIG. 3.—*Cyclops (Apocyclops) dengizicus* Lepechkin ? ♂. (Abd Imam).  
a. Furca, face ventrale ; b. Enp. 4 ; c. P 5 et P 6.

insérées loin l'une de l'autre par suite de l'épaisseur de l'article, présentent par ce fait une configuration si aberrante des autres animaux rangés dans le sous-genre *Metacyclops* de Kiefer qu'il semble tout à fait désordonné de les maintenir parmi eux, puisque c'est justement la cinquième patte qui a servi de base pour l'établissement des divers sous-genres du genre *Cyclops*. Déjà Gurney avait fait remarquer ce manque de logique. A fin de continuer l'emploi de préfixes grecques je propose le terme de *Apocyclops* pour désigner le sous-genre nouveau dans lequel il convient

de grouper les 3 espèces connues jusqu' à présent à cinquième patte ressemblant à celle de *C. dengizicus* Lepechikine, les deux autres étant *C. (A.) panamensis* Marsh et *C. (A.) royi* Lindberg.

#### XV. CONTRIBUTION À LA CONNAISSANCE DE *MESOCYCLOPS LEUCKARTI* CLAUS.

Du total de 257 verres renfermant des Cyclopidés récoltés pendant l'hiver 1939-40, le *M. leuckarti* s'est trouvé dans 57 (soit environ 22 pour cent). Mais, tandis qu'il a été présent dans 41, représentant 28 localités des 152 tubes du Sud de l'Iran (26.9 pour cent), il n'en a été trouvé que dans 16 (de 8 localités) des 105 échantillons du Nord (15.2 pour cent). L'observation courante que le *M. leuckarti* est plus commun dans les pays chauds que dans les zones tempérées a ainsi trouvé une confirmation aussi dans ce pays de climats variés. De plus, il faut mentionner que dans plusieurs habitats du Sud le *M. leuckarti* était abondant, mais, qu'avec une seule exception, il n'a été trouvé qu'en très petit nombre dans le Nord et l'exception en question était vraiment de nature à confirmer la règle, puisque l'habitat dont il s'agissait était un bassin rempli d'eau industrielle dont la température semblait être d'environ 40° C. et dans laquelle fourmillaient des copépodites de notre espèce (quelques *M. leuckarti* adultes s'y trouvaient aussi, mais aucun autre Cyclopide).

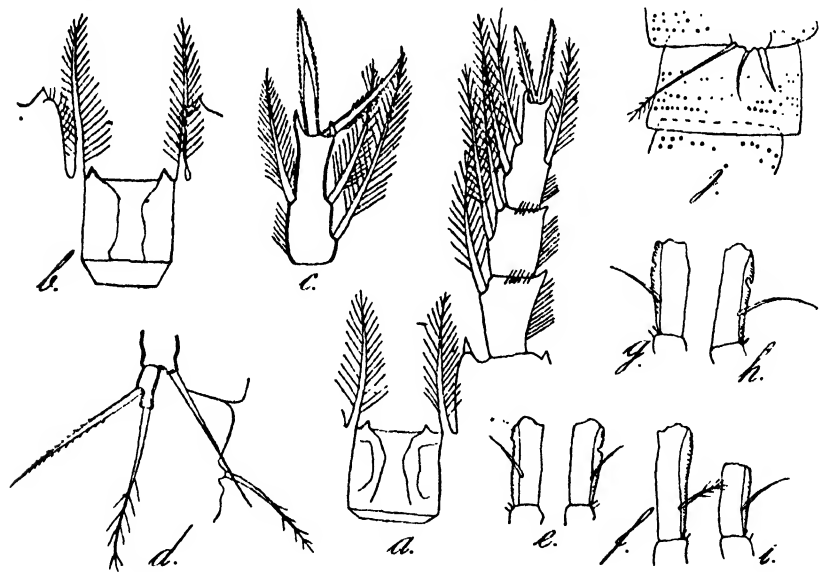


FIG. 4.—*Mesocyclops leuckarti* Claus.

a. ♀ Lamelle basale et endopodite de la quatrième paire de pattes (Ahvaz, mare); b. ♀ Lamelle basale de la quatrième paire de pattes (Nakhl Taqi-Tahiri, puits); c. ♀ Article 3 de l'ant. 4 (Firouzabad, bassin); d. ♀ P 5 (Ahvaz, bassin); e. ♀ Première antenne, article 17, côté gauche et côté droit (Ahvaz, bassin); f. ♀ Do. (Zirhak, puits); g. ♀ Do. (Béhbéhan, citerne); h. ♀ Do. (Ali, puits); i. ♀ Do. (Ahvaz, mare); j. ♂ P 6 (Zirhak, puits).

L'étude de divers individus a montré le polymorphisme usuel de *M. leuckarti*, sans qu'il ait semblé possible de différencier des sous-

espèces ou des variétés. Cependant une distinction générale a pu être établie entre les spécimens du Nord et ceux du Sud, tout en admettant le manque de caractères distinctifs absolus et l'existence de formes de passage.

Les points principaux envisagés seront mentionnés dans la suite. Les mensurations de quelques animaux récoltés en 1935 ont été ajoutées (de Lar 3 mâles, 4 femelles, et de Khorramchahr 2 mâles, une femelle). Ceux-ci avaient d'abord été décrits comme appartenant à une espèce différente, le *M. iranicus*, distinction qu'il ne me semble plus justifié à maintenir, et ce nom doit désormais être considéré comme un synonyme de *M. leuckarti*. Les résultats des mensurations de certains rapports se trouvent résumés dans le tableau. Bien que les chiffres ne sont pas tout à fait comparables, peu d'animaux du Nord ayant été étudiés, il semble pourtant ressortir des données obtenues qu'une distinction de deux formes ou races, septentrionale et méridionale, puisse se faire.

*Femelle.*—Selon la longueur du corps (sans les soies apicales) les 45 spécimens mesurés se sont répartis ainsi :

Longueur en $\mu$	..	..	..	..	..	..	..	..	Nombre.
800 à 900	..	..	..	..	..	..	..	..	1
900 à 1000	..	..	..	..	..	..	..	..	..
1000 à 1100	..	..	..	..	..	..	..	..	3
1100 à 1200	..	..	..	..	..	..	..	..	3
1200 à 1300	..	..	..	..	..	..	..	..	9
1300 à 1400	..	..	..	..	..	..	..	..	8
1400 à 1500	..	..	..	..	..	..	..	..	7
1500 à 1600	..	..	..	..	..	..	..	..	11
> 1600	..	..	..	..	..	..	..	..	3

- (2) Chez plusieurs animaux de la région du Golfe Iranien les 3 premiers segments abdominaux surtout ont présenté sur les deux faces des rangées irrégulières de petites fossettes ; chez ceux du puits situé entre Tahirî et Nakhl Taqi ces fossettes étaient évidentes aussi sur le thorax et sur les antennes des deux sexes. Au lieu de dépressions les spécimens du puits à Zirhak montraient de petites verrues ou spinules sur les deux côtés de tous les segments abdominaux.
- (3) Les branches de la furca ont presque toujours été légèrement divergentes. Leur rebord interne a porté des poils, parfois disposés en 4 groupes, chez 22 des 36 spécimens du Sud examinés à ce propos (61 pour cent) ; aucun des 7 animaux du Nord n'a montré la présence de poils. La forme septentrionale, tout en étant plus petite, a aussi montré une furca plus courte que celle des animaux du Sud, et sa soie dorsale a été légèrement inférieure en longueur ; cette soie a parfois été fortement ciliée chez les échantillons du Sud.
- (4) Quelques spécimens du Sud et le mâle et la femelle de Sari dans le Nord ont montré une modification en lancette de la plupart des épines des exopodites des pattes natatoires.
- (5) L'article 3 de l'emp. 4 a chez les animaux du Nord semblé un peu moins allongé et les deux épines apicales ont présenté peu de différence de longueur entre elles du fait que l'épine apicale externe s'est trouvée plus longue chez les exemplaires des



provinces Caspiennes que chez ceux du Sud. Par suite du peu de longueur de l'article lui-même, celui-ci n'a surpassé que légèrement celle de l'épine apicale interne dans le cas des spécimens septentrionaux, et chez un seul d'entre eux la longueur de l'épine apicale interne a été supérieure à celle de l'article, fait que jé n'ai jusqu'à présent jamais observé chez les échantillons de *M. leuckarti* récoltés dans l'Inde. Dans le cas des animaux du Sud de l'Iran l'article a le plus souvent été considérablement plus long que l'épine apicale interne.

- (6) Les deux épines faisant saillie au-dessus du bord libre de la lamelle réunissant la base de la quatrième paire de pattes a été présentes chez tous les animaux, mais leurs dimensions, tant en ce qui concerne leur largeur que leur hauteur, ainsi que leur forme, ont montré de nombreuses variations, aussi bien chez les individus du Sud que chez ceux du Nord.
- (7) Dans la structure de la cinquième patte je n'ai pas observé de modifications importantes.
- (8) La membrane hyaline située au niveau du dix-septième article de la première antenne a présenté un grand nombre d'aspects variés, dont quelques uns ont été reproduits sur les figures.
- (9) L'aspect perlé du deuxième maxillipède a été très distinct chez tous les animaux examinés.
- (10) Le réceptacle séminal a montré de nombreuses variations.
- (11) Les ovisacs ont le plus souvent été grands, écartés, et parfois dépassant l'extrémité de la furca. J'ai compté chez 13 individus une moyenne de 24 oeufs dans un sac. Chez ceux-ci le minimum d'oeufs a été de 10 et le maximum de 48 (spécimen d'une petite mare. à Ahvaz).

*Mâle*.—Les animaux mesurés se sont groupés ainsi selon la longueur de leur corps (sans soies apicales) :

Longueur en $\mu$	..	..	..	..	..	..	..	..	Nombre
700 à 800	..	..	..	..	..	..	..	..	5
800 à 900	..	..	..	..	..	..	..	..	9
900 à 1000	..	..	..	..	..	..	..	..	9
1000 à 1100	..	..	..	..	..	..	..	..	11
> 1100	..	..	..	..	..	..	..	..	3

- (2) Les fossettes de la cuticule mentionnées au sujet de la femelle ont été présentes également chez le mâle des mêmes habitats.
- (3) Le rebord interne des branches de la furca a été dépourvu de poils chez tous les spécimens examinés sans exception, et cela aussi chez les mâles des biotopes où toutes les femelles appartenaient à la "forma pilosa". La soie dorsale par contre a été trouvée ciliée chez la plupart des animaux.
- (4) Les variations de l'article 3 de l'emp. 4 et de ses appendices ont, d'une façon générale, été comparables à celles observées chez la femelle.
- (5) Les 3 appendices de la sixième patte ont été en moyenne plus longs chez les animaux du Sud que chez ceux du Nord. Chez 2 spécimens du Sud la longueur de l'épine interne a dépassé 40 $\mu$ , mais ces individus et les femelles du même habitat ne présentaient autrement rien de distinctif.

*Habitats.*—Dans le Sud de l'Iran le *M. leuckarti* s'est trouvé de préférence dans les puits, les bassins et les citernes. Selon les habitats il se répartissait ainsi :

Puits à l'eau douce .. .. .	11 (Sud).
Puits à l'eau saumâtre .. .. .	6 (Sud).
Bassins .. .. .	10 (Sud 7, Nord 3).
Réservoirs à ciel ouvert .. .. .	5 (Sud).
Réservoir à toit .. .. .	3 (Sud).
Étangs d'eau douce .. .. .	3 (Nord).
Rizières .. .. .	2 (Nord).
Marais d'eau douce .. .. .	3 (Sud 2, Nord 1)
Marais d'eau saumâtre .. .. .	1 (Nord).
Mares d'eau douce .. .. .	3 (Nord).
Mares d'eau saumâtre .. .. .	2 (Sud).
Fosses d'eau douce .. .. .	2 (Sud 1, Nord 1).
Bras-mort de canal d'irrigation .. .. .	1 (Sud).
Mares de rivière d'eau douce .. .. .	2 (Sud 1, Nord 1).
Mare de rivière d'eau saumâtre .. .. .	1 (Sud).
Ruisseau d'eau douce .. .. .	1 (Nord).
Rivière d'eau saumâtre .. .. .	1 (Sud).

*Liste des localités.*—Sud : Ahvaz, Akhtar, Assalou, Béhbéhan, Bender Chahpour, Birikou, Borazdjan, Boukhéir, Chouch (Suse), Dar-ol-Mizan, Darquoin, Dayyir, Djam, Firouzabad, Gahi, Gorgor, Hadakou, Karri, Khorab, Khorramchahr, Kourdéh Ouli (Ali), Pouzéh, Réchir, Tahiri, Tang-Gaz, Tehabadi, Zirhak. Nord : Bender Gaz, Chahi, Gorgan, Lahidjan, Langueroud, Ramsar, Recht, Sari.

#### XVI. NOTES SUR *MESOCYCLOPS RYLOVI* SMIRNOV ET *MESOCYCLOPS VERMIFER* LINDBERG.

Dans un assez grand nombre de localités surtout du Sud de l'Iran j'ai trouvé un *Thermocyclops* montrant les caractéristiques essentielles de *M. (Th.) rylovi* Smirnov. Cependant certains de ces animaux ont présenté quelques différences, notamment dans la structure du segment génital, celle de la furca et de ses appendices et celle de l'article 3 de l'emp. 4, les rapprochant de *M. (Th.) vermifer* de l'Inde. Ces différences sont les suivantes :

Taille plus petite et moins robuste.

Segment génital plus étroit et allongé, principalement par suite de sa moindre largeur proximale.

Furca moins longue.

Soie dorsale [le plus souvent ciliée comme chez *M. (Th.) rylovi*] plus longue.

Soie apicale interne de la furca plus longue et soie apicale externe plus courte, donnant un rapport de longueur plus élevé entre ces deux soies [moyenne 2.75 : 1, tandis que cette moyenne est typiquement de 2.29 : 1 ou moins chez *M. (Th.) rylovi*],

Peu de différence de longueur entre la soie apicale médiane externe et la soie apicale interne.

Article 3 de l'enp. 4 plus allongé.

Épine apicale interne de cet article plus longue et épine apicale externe plus courte, l'épine apicale interne parfois surpassant en longueur celle de l'article.

Différence de longueur entre l'épine et la soie de l'article 2 de P 5 moins grande.

Première antenne atteignant le plus souvent le milieu du troisième segment thoracique et parfois le bord postérieur de ce segment. [Chez *M. (Th.) rylovi* elle atteint en général le bord postérieur du deuxième segment thoracique et fréquemment le milieu de ce segment.]

Épine interne de P6 chez le mâle un peu plus courte et, soie externe de P6 beaucoup plus longue.

Aucune de ces caractéristiques ne semble cependant avoir par elle-même une valeur diagnostique absolue et ce n'est que la coexistence de tous ou de plusieurs de ces points structuraux qui puisse différencier de *M. (Th.) rylovi* les animaux dont il s'agit. Leur similitude avec *M. (Th.) vermifer* est si grande que je me sens contraint de les identifier avec cette espèce indienne. Toutefois il faut dire que la question de systématique qui est en jeu ici ne me semble pas encore résolue d'une manière définitive.

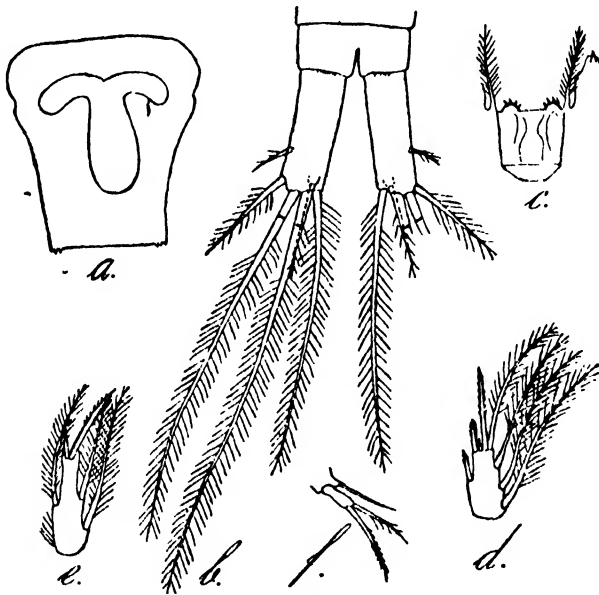


FIG. 5.—*Mesocyclops (Thermocyclops) rylovi* Smirnov. ♀ (Nakhl Taql).  
a. Segment génital; b. Furca, face ventrale; c. Lamelle basale de P 4; d. Article 3 exp. 4; e. Article 3 enp. 4; f. P 5.

Au moment de la découverte de *M. (Th.) vermifer* j'ai aussitôt été frappé par sa ressemblance avec la description et les figures de Smirnov de *M. (Th.) rylovi* et je l'ai d'abord décrit comme en étant une variété.

Plus tard, grâce à l'obligeance du Dr. Smirnov, j'ai pu moi-même comparer ces animaux indiens avec deux échantillons de *M. (Th.) rylovi* provenant de Tiflis. Ces derniers étaient notablement plus robustes,

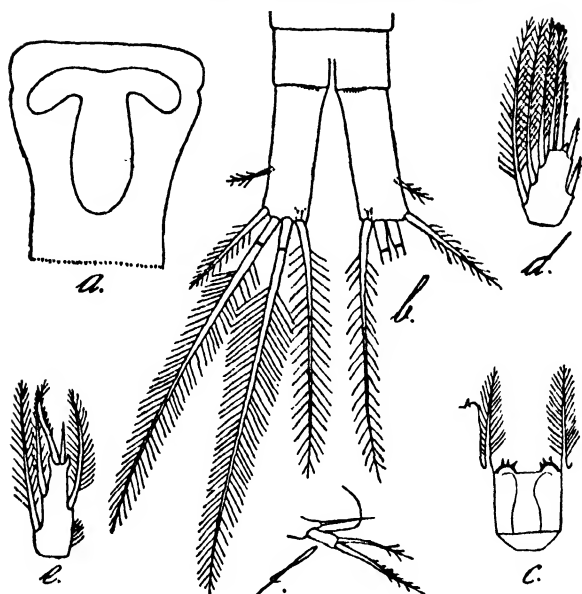


FIG. 6.—*Mesocyclops (Thermocyclops) rylovi* Smirnov. ♀ (Tiflis).

a. Segment génital; b. Furca, face ventrale; c. Lamelle basale de P 4; d. Article 3, exp. 4; e. Article 3, enp. 4; f. P. 5.

à segment génital plus élargi, à furca plus longue, avec des rapports de longueur des soies apicales différents, à article terminal de

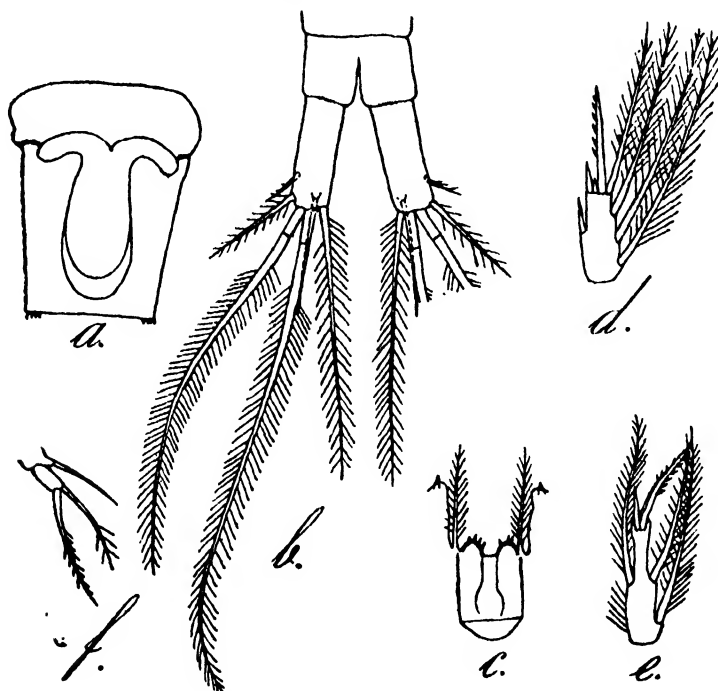


FIG. 7.—*Mesocyclops (Thermocyclops) vermifer* Lindberg. ♀ (Pouzéh).

a. Segment génital; b. Furca, face ventrale; c. Lamelle basale de P 4; d. Article 3, exp. 4; e. Article 3, enp. 4; f. P. 5.

l'enp. 4 moins allongé, à épine apicale interne plus courte et épine apicale externe plus longue etc. Ces différences ont été si marquées que j'ai dès lors cru nécessaire de considérer *M. (Th.) vermifer* non pas comme une variété de *M. (Th.) rylovi* mais comme une espèce distincte.

Il convient maintenant de dire que *M. (Th.) rylovi* a été décrit d'après des spécimens femelles de 2 localités seulement du Caucase et que par conséquent la description originale n'a pas pu fournir des renseignements sur l'amplitude des variations morphologiques. Comme l'espèce en question a évidemment une répartition géographique très étendue on peut naturellement s'attendre à des variations importantes.

Le résultat auquel je suis arrivé après l'étude des animaux iraniens est la suivante : Plusieurs d'entre eux sont identiques aux animaux de Tiflis, *M. (Th.) rylovi* ; d'autres à *M. (Th.) vermifer*. Quelques uns ont à certains égards les caractéristiques de formes de passage entre ces deux espèces, tout en se rapprochant plus de l'une d'elles que de l'autre.

Kiefer attribue une grande valeur diagnostique à la structure de la lamelle basale de la quatrième paire de pattes chez les *Thermocyclops*.

En regardant les figures de Kiefer, par exemple dans son article sur les Cyclopides d'Angola, on voit comment un aspect tout à fait distinctif a été donné pour chaque espèce (*Th. decipiens*, *infrequens*, *consimilis*, *neglectus* etc). Il faut cependant prendre note de ce que les études de Kiefer de ces animaux africains ont en général été faites sur un

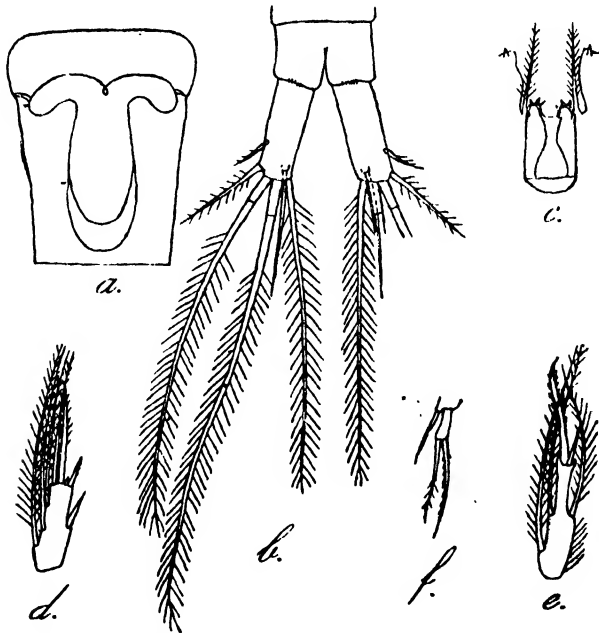


FIG. 8.—*Mesocyclops (Thermocyclops) vermifer* Lindberg. ♀ (Tahiri).

a. Segment génital ; b. Furca, face ventrale ; c. Lamelle basale de P 4 ; d. Article 3, exp. 4 ; e. Article 3, enp. 4 ; f. P 5.

assez petit nombre d'exemplaires et provenant de peu de localités différentes. Dans des conditions pareilles il est bien vrai que tout peut

sembler simple et les caractéristiques observées peuvent apparaître bien définies et absolues. On peut rappeler ici la remarque de Chappuis au sujet des vues de Lowndes, que cet auteur semble être arrivé à la conclusion paradoxale que "plus la description d'un animal est détaillée plus l'animal devient méconnaissable" ou en d'autres mots, l'espèce la mieux définie est celle qui n'est connue par un spécimen unique. En effet l'étude de nombreux exemplaires de provenances diverses aboutit souvent à un élargissement des caractéristiques d'une certaine espèce, montrant la nécessité de supprimer des formes décrites d'abord comme des entités distinctes, quand on s'aperçoit que les particularités de celles-ci se trouvent en réalité dans les limites de variation de l'espèce en question. Le jour que nos connaissances des *Thermocyclops* du continent africain seront complètes, il est bien probable que le résultat en sera une réduction notable du nombre des "espèces" déjà décrites. C'est quand on dispose d'animaux nombreux, provenant d'un grand nombre de localités différentes, que la distinction d'espèces cesse d'être simple et qu'on se rend compte de la valeur douteuse de certains traits de structure par suite de l'amplitude de leurs variations. Il en est ainsi notamment en ce qui concerne la lamelle basale de la quatrième paire de pattes, et aussi, mais à un moindre degré, pour le réceptacle séminal. Je l'ai déjà montré au sujet de *M. (Th.) hyalinus* et de *M. (Th.) vermifer* de l'Inde. Sur les figures sont représentés ici un certain nombre d'aspects différents chez *M. (Th.) rylovi* et *M. (Th.) vermifer* de l'Iran. Très

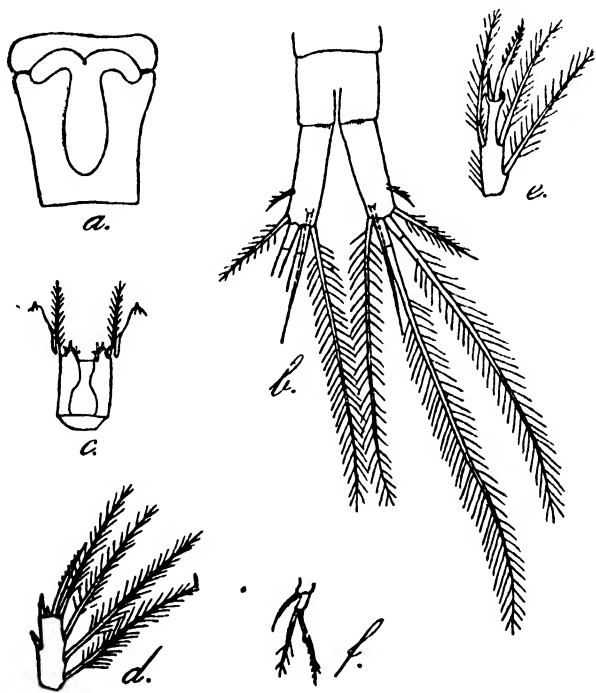


FIG. 9.—*Mesocyclops (Thermocyclops) vermifer* Lindberg. ♀ (Vangarvadi Deccan).

a. Segment génital ; b. Furca, face ventrale ; c. Lamelle basale de P 4 ; d. Article 3, exp. 4 ; e. Article 3, enp. 4 ; f. P 5.

souvent on voit des animaux chez lesquels les deux éminences latérales ne sont pas de structure identique, mais différant l'une de l'autre, et j'ai même rencontré un spécimen de *M. (Th.) rylovi* chez lequel l'une de ces élevures avait l'aspect caractéristique de *M. (Th.) hyalinus*, tandis que l'autre était du type de *M. (Th.) vermifer*.

J'ai parlé ailleurs de la distinction entre *M. (Th.) vermifer* et *M. (Th.) decipiens* Kiefer sans toutefois souligner la différence réelle qui existe entre ces deux espèces dans la structure du réceptacle séminal. Celui de *M. (Th.) decipiens* est en somme, d'après les figures de Kiefer, assez caractéristique : les bras latéraux sont presque horizontaux, à courbure très faible, à angle formé avec la partie verticale très ouvert. Chez *M. (Th.) vermifer*, de même que chez *M. (Th.) rylovi* [et du reste aussi chez *M. (Th.) mongolicus* et *M. (Th.) analogus*] les bras latéraux sont bien plus recourbés et l'angle en question beaucoup plus aigu. Comme je l'ai déjà fait remarquer ailleurs *M. (Th.) analogus* est manifestement un *M. (Th.) vermifer* à longue furca, tandis que *M. (Th.) mongolicus* (décrit de 2 femelles d'une localité unique ?) semble représenter une de ces formes de passage à qui il est bien difficile, à l'état actuel de nos connaissances, d'assigner une place certaine, mais qui semble se rapprocher plus de *M. (Th.) vermifer* que de *M. (Th.) rylovi*.

#### **Mesocyclops (Thermocyclops) rylovi** Smirnov.

*Habitats*.—Abd Imam, puits à l'eau saumâtre, étang d'eau douce ; Assalou, étang salin, puits à l'eau douce ; Dayyir, puits à l'eau

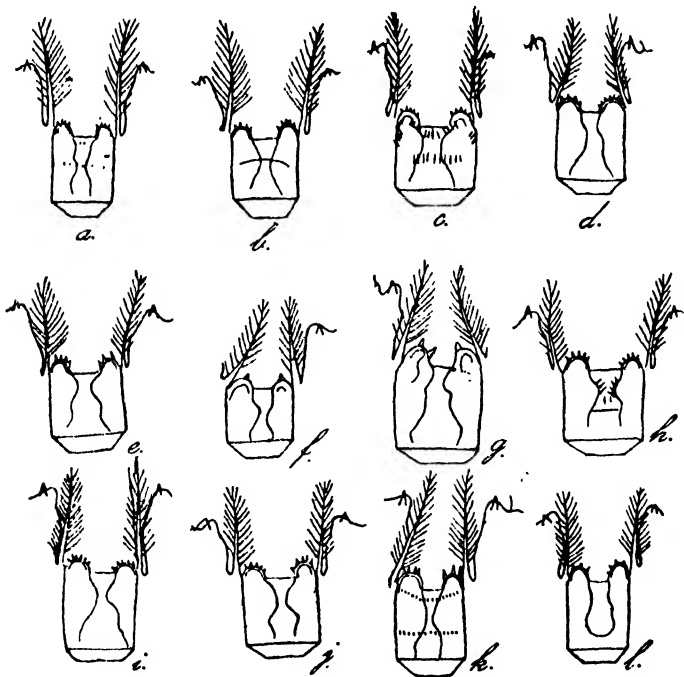


FIG. 10.—*Mesocyclops (Thermocyclops) rylovi* Smirnov. ♀ Lamelle basale de P 4.

a. b. Abd Imam, étang ; c. Abd Imam, puits ; d. Tadjoumelkéh. e. f. g. Khorram-chahr ; h. Assalou, étang ; i. Isfahan ; j. Assalou, puits ; k. Hadakou ; l. Gorgan.

saumâtre ; Guénavéh, mare d'eau saumâtre ; Hadakou, puits à l'eau douce ; Isfahan, bassin ; Nakhl Taqi, étang d'eau douce, étang salin ; Réchir (Bouchir), mare de rivière à Païtell ; Tadjoumelkéh, puits à l'eau saumâtre ; Khorramchahr, ruisseau (sept. 1935). Gorgan, mare ; Recht, ruisseau.

**Mesocyclops (Thermocyclops) vermifer** Lindberg.

*Habitats.*—Ahvaz, bassin ; Ali (Ouli), puits à l'eau douce ; Assalou, réservoir voûté ; Béhbéhan, citerne d'un puits à l'eau saumâtre, puits à l'eau saumâtre, bassin ; Bender Rig, puits à l'eau saumâtre ; Dilvar, puits à l'eau saumâtre ; Galléhdar, réservoir d'eau douce ; Parak, mare

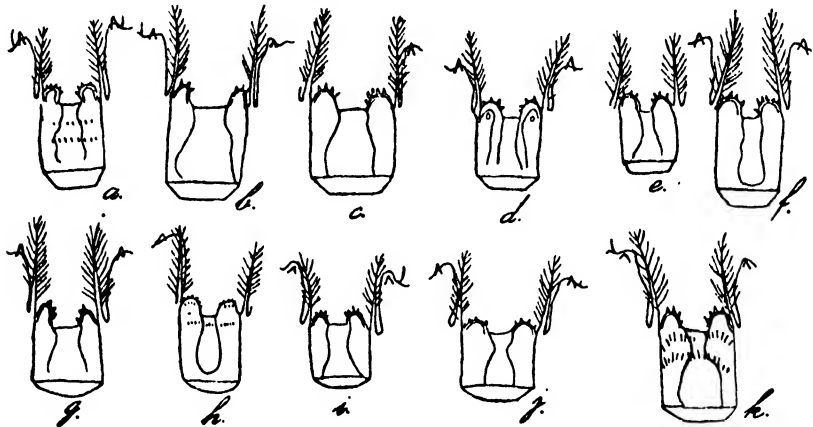


FIG. 11.—*Mesocyclops (Thermocyclops) vermifer* Lindberg. ♀ Lamelle basale de P 4.

a. Tahiri, puits ; b. Tang-Qil ; c. Pouzé ; d. Béhbéhan, bassin ; e. Béhbéhan, puits ; f. Assalou, réservoir ; g. Tahiri, réservoir ; h. Ahvaz ; i. Ali ; j. Sari ; k. Galléhdar.

d'eau douce, étang salin ; Pouzé, puits à l'eau douce ; Réchir (Bouchir), puits à l'eau douce ; puits à l'eau douce entre Tahiri et Nakhl Taqi ; Tahiri, réservoirs d'eau douce (2) ; puits à l'eau douce ; mare d'eau douce ; Tang-Qil, réservoir d'eau douce à ciel ouvert ; Tchabadi, marais d'eau douce ; Linguéh, puits à l'eau saumâtre (oct. 1935).

Béhchahr, bassin ; Chahi, étang ; Sari, bassin.

XVII. DESCRIPTION D'UN *THERMOCYCLOPS* NOUVEAU.

**Mesocyclops (Thermocyclops) microspinulosus**, sp. nov.

*Description.*—Longueur de la femelle ovigère de 1178 à 1306  $\mu$  (4 spécimens mesurés). Cuticule des 3 premiers segments abdominaux ornementée sur les deux faces de rangées de petites fossettes. Des dépressions semblables se trouvent aussi sur les maxillipèdes et leur donnent un peu l'aspect perlé, caractéristique de *M. leuckarti*. Ces fossettes sont encore plus marquées chez les animaux immatures que chez les adultes. Segment génital plus long que large. Le rebord postérieur du quatrième segment abdominal semble dépourvu sur la face



ventrale du groupe usuel de petites épines. Furca à branches divergentes, de 2.72 à 3.40 fois aussi longues que larges. Soie dorsale moins longue que la soie apicale externe. Soie apicale interne plus de deux fois, mais moins de deux fois et demi aussi longue que la soie apicale externe. Première antenne à 17 articles, rabattue elle atteint le milieu ou plus rarement le rebord postérieur du deuxième segment thoracique. Rapport entre la longueur et la largeur de l'article terminal de l'enp. 4 assez variable. L'épine apicale interne peut être un peu plus longue que l'article, mais le plus souvent elle en est inférieure en longueur. Epine apicale interne moins que deux fois aussi longue que l'épine apicale externe. Lamelle basale de la quatrième paire de pattes à élevures latérales régulièrement arrondies, de saillie assez faible et munies d'épines minuscules. Cinquième patte à épine apicale nettement plus longue que la soie. (Rapport épine : soie chez 4 individus, 1.34, 1.34, 1.40 et

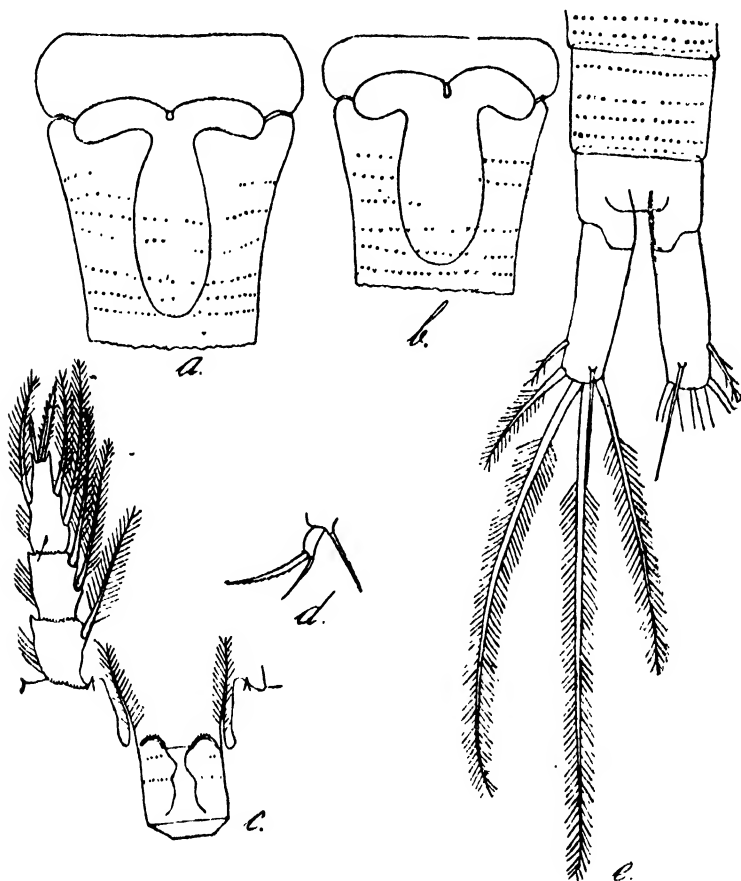


FIG. 12.—*Mesocyclops (Thermocyclops) microspinulosus* sp. nov. ♀.

a, b. Segment génital; c. Lamelle basale et cnp. 4; d. P 5; e. Furca, face dorsale.

1.76 : 1). Réceptacle séminal un peu variable, ressemblant plutôt à celui de *M. (Th.) rylovi* Smirnov. Les ovisacs semblaient contenir peu d'oeufs, mais n'étaient complets chez aucun des animaux examinés.

*Mâle*.—Un seul trouvé de 846  $\mu$  de longueur. Furca à branches divergentes. Soie dorsale plus longue que la soie apicale externe de la furca. Sixième patte rudimentaire formée d'une épine interne, d'une soie médiane et d'une soie externe, qui est l'appendice le plus long, dépassant légèrement le bord postérieur du deuxième segment abdominal. L'épine n'a malheureusement pas pu être mesurée correctement. Elle se trouvait englobée dans du detritus très adhérent et a été endommagée des deux côtés au cours des tentatives faites pour la dégager.

*Habitat*.—Une citerne d'eau de puits saumâtre près de la ville de Bouchir. Récolté en petit nombre au mois de février.

*Remarques*.—Ce qui caractérise la forme qui vient d'être décrite ce n'est pas en premier lieu la présence de rangées de fossettes. Une ornementation de ce genre se voit chez certains individus (races ?) de plusieurs espèces de Cyclopides, qui normalement présentent une cuticule lisse. Parmi les *Mesocyclops* j'ai observé des fossettes ou de petites épines chez *M. leuckarti* et chez des *Thermocyclops* iraniens répondant à la description de *M. (Th.) rylovi* Smirnov. La structure de la furca, du segment génital, du réceptacle séminal, de la cinquième patte et de l'article terminal de l'emp. 4 n'offre rien de très distinctif et leur configuration et rapports se trouvent dans les limites de variation de *M. (Th.) rylovi*. Mais jusqu'à présent je n'ai pas observé chez ces animaux un aspect pareil de la lamelle basale de P 4, les éminences latérales étant autrement toujours munies de fortes épines, tandis que ces épines sont très exiguës chez *M. (Th.) microspinulosus*. Cependant c'est à titre provisoire que la forme présente a été décrite comme une espèce distincte. Elle se rapproche certainement beaucoup de *M. (Th.) rylovi* Smirnov.

#### XVIII. TABLEAUX ANALYSÉS DE DEUX COLLECTIONS DE CYCLOPIDES.

En ce qui concerne les Copépodes Cyclopides, l'Iran a jusqu'à ces dernières années été l'une des régions les moins connues. Cependant, par suite de sa situation géographique et de ses particularités climatiques, il semble que c'est justement dans ce pays que leur étude serait éminemment intéressante. Nos connaissances de la répartition en Europe des animaux du groupe en question sont sans doute assez complètes, et je crois que la grande majorité des Cyclopides vivant dans l'Inde ont également déjà été identifiés. Puisque l'Iran se relie à l'Europe par le Caucase et à l'Inde par le Beloutchistan, la question principale que l'étude de ses Copépodes serait susceptible d'éclaircir, semble bien être celle du rôle possible de ce pays comme lieu de rencontre pour la faune arctique de l'Europe avec la faune tropicale de l'Inde. A part les quelques espèces cosmopolites qui se trouvent aussi bien en Europe que dans l'Inde, ces deux parties du globe présentent en effet, abstraction faite du Cachemire qui géographiquement ne fait pas partie de la péninsule indienne, deux régions faunistiques bien distinctes. Il est vrai que des espèces arctiques, telles que *Acanthocyclops robustus* et *Acanthocyclops languidus*, ont été rapportées du Ceylan par les auteurs d'il y a quelques décades, mais leur présence n'y a depuis jamais été confirmée, ni celle de *Microcyclops bicolor* et de *Thermocyclops oithonoides*.

autres formes de distribution surtout arctique, dont l'existence dans l'Inde semble également douteuse.

Climatiquement l'Iran peut se diviser en 3 zones principales : celle des provinces Caspiennes, à forte humidité et à variations de température faibles ; celle du plateau, aride et sujette aux grandes extrêmes de température ; enfin celle du littoral du golfe Iranien, torride en été et tempéré en hiver, à humidité d'une façon générale assez élevée. En considérant température et précipitation atmosphérique il n'y a en Europe aucune région comparable à celle de la côte méridionale de la mer Caspienne, et il n'y a guère de partie de l'Inde où l'on observe des températures dépassant 50° C. en été et pouvant s'abaisser de plusieurs degrés au-dessous du 0 en hiver, comme c'est le cas dans le Sud de l'Iran. Enfin, le climat continental du plateau ne ressemble qu'à celui de l'Asie centrale, ni l'Europe, ni l'Inde en possédant l'équivalent. Les faits climatiques étant tels, si des représentants des deux branches biogéographiques mentionnées puissent se rencontrer en Iran, sera-ce dans le Nord, ou aussi bien la faune que la flore se rapprochent de celles de l'Europe, sur le plateau, ou dans le Sud, de caractère tropical ?

L'étude de deux collections de Cyclopidés de l'Iran ayant été achevée il est maintenant possible d'en dresser le tableau complet, afin d'obtenir une vue d'ensemble sur la répartition des animaux identifiés et chercher à trouver une réponse à la question qui vient d'être posée.

Les récoltes faites en septembre, octobre et début de novembre 1935 dans 30 habitats, représentant 11 stations, avaient donné 14 espèces. Celles de l'hiver 1939-40, comprenant 256 verres de 92 localités, en avaient ramené 39, le total étant de 40 espèces rapportées de 286 habitats, situés dans 100 localités différentes, 46 du Sud, 39 du plateau et de l'Est et 15 des provinces Caspiennes. Les pêches de 1935 provenaient de quelques localités du Sud, du plateau central et de l'Est, celles de 1939-40 du Sud, du plateau et des provinces Caspiennes.

En donnant ci-dessous le tableau montrant la distribution des espèces trouvées, il faut faire remarquer que j'ai suivi la classification et la nomenclature de Kiefer avec deux modifications. Les animaux du sous-genre *Diacyclops* Kiefer ont été rangés dans le sous-genre *Acanthocyclops* Kiefer, la caractéristique donnée pour les séparer étant si peu marquée, puisqu'elle dépend uniquement de la longueur de l'épine de P 5, que leur distinction ne semble pas justifiée. D'autre part j'ai créé un sous-genre nouveau, *Apocyclops* pour grouper *C. dengizicus* Lepechkin et les espèces semblables, la structure de leur P 5 étant foncièrement différente de celle des membres du sous-genre *Melacyclops*, parmi lesquels ils avaient été placés par Kiefer.

L'ordre de fréquence pour tout le pays des espèces récoltées se voit aisément sur ce tableau, mais, au lieu de considérer l'Iran en entier, il est plus intéressant d'opposer les pêches faites dans les provinces Caspiennes à celles provenant des autres parties du pays. Les 23 espèces les plus communes se rangent alors dans l'ordre suivant selon leur fréquence extensive :

Sud. Plateau. Est.		Provinces Caspiennes.	
Stations.	Habitats.	Stations.	Habitats.
<i>Metacyclops minutus</i> ..	<i>Metacyclops minutus</i>	<i>Acanthocyclops bicuspidatus</i> ..	<i>Megacyclops viridis</i>
<i>Mesocyclops leuckarti</i> ..	<i>Eucyclops serrulatus</i>	<i>Megacyclops viridis</i> ..	<i>Acanthocyclops bicuspidatus</i>
<i>Eucyclops serrulatus</i> ..	<i>Mesocyclops leuckarti</i>	<i>Eucyclops serrulatus</i> ..	<i>Eucyclops serrulatus</i>
<i>Thermocyclops vermifer</i> ..	<i>Cyclops strenuus divergens</i>	<i>Acanthocyclops bisetosus</i> ..	<i>Acanthocyclops bisetosus</i>
<i>Cyclops strenuus divergens</i> ..	<i>Thermocyclops vermifer</i>	<i>Mesocyclops leuckarti</i> ..	<i>Mesocyclops leuckarti</i>
<i>Megacyclops viridis</i> ..	<i>Megacyclops viridis</i>	<i>Microcyclops varicans</i> ..	<i>Microcyclops varicans</i>
<i>Thermocyclops rylowi</i> ..	<i>Metacyclops planus</i>	<i>Acanthocyclops vernalis</i> ..	<i>Acanthocyclops vernalis</i>
<i>Metacyclops grandispinifer</i> ..	<i>Thermocyclops rylowi</i>	<i>Paracyclops vagus</i> ..	<i>Macrocyclus albidus</i>
<i>Metacyclops planus</i> ..	<i>Acanthocyclops bicuspidatus odessanus</i>	<i>Microcyclops linjanticus</i> ..	<i>Ectocyclops rubescens</i>
<i>Acanthocyclops bicuspidatus odessanus</i>	<i>Metacyclops grandispinifer</i>	<i>Macrocyclus albidus</i> ..	<i>Paracyclops vagus</i>
<i>Microcyclops varicans</i> ..	<i>Acanthocyclops bicuspidatus</i>	<i>Ectocyclops rubescens</i> ..	<i>Acanthocyclops robustus</i>
<i>Thermocyclops tinctus</i> ..	<i>Microcyclops varicans</i>	<i>Cyclops strenuus divergens</i> ..	<i>Metacyclops planus</i>
<i>Acanthocyclops bicuspidatus</i> ..	<i>Thermocyclops tinctus</i>	<i>Acanthocyclops robustus</i> ..	<i>Microcyclops linjanticus</i>
<i>Tropocyclops confinis</i> ..	<i>Eucyclops rutnici elburziensis</i>	<i>Metacyclops planus</i> ..	<i>Macrocyclus fuscus</i>
<i>Paracyclops fimbriatus</i> ..	<i>Paracyclops fimbriatus</i>	<i>Thermocyclops vermifer</i> ..	<i>Cyclops strenuus divergens</i>
<i>Microcyclops linjanticus</i> ..	<i>Tropocyclops confinis</i>	<i>Thermocyclops dybowskii</i> ..	<i>Cyclops caspicus</i>
<i>Eucyclops rutnici elburziensis</i>	<i>Ectocyclops rubescens</i>	<i>Thermocyclops rylowi</i> ..	<i>Thermocyclops vermifer</i>
<i>Ectocyclops rubescens</i> ..	<i>Microcyclops linjanticus</i>	<i>Macrocyclus fuscus</i> ..	<i>Acanthocyclops bicuspidatus odessanus</i>
<i>Acanthocyclops bisetosus</i> ..	<i>Acanthocyclops bisetosus</i>	<i>Cyclops caspicus</i> ..	<i>Thermocyclops dybowskii</i>
<i>Apocyclops denigricus</i> ..	<i>Apocyclops denigricus</i>	<i>Acanthocyclops bicuspidatus odessanus</i>	<i>Thermocyclops rylowi</i>
<i>Macrocyclus albidus</i> ..	<i>Macrocyclus albidus</i>	<i>Eucyclops macruiroides</i> ..	<i>Eucyclops macruiroides</i>
<i>Eucyclops euacanthus</i> ..	<i>Eucyclops euacanthus</i>	<i>Cyclops kozminskii</i> ..	<i>Cyclops kozminskii</i>
<i>Paracyclops vagus</i> ..	<i>Paracyclops vagus</i>	<i>Metacyclops minutus</i> ..	<i>Metacyclops minutus</i>

La distinction des provinces Caspiennes du restant de l'Empire n'est cependant pas absolument juste. Les conditions particulières mentionnées y s'appliquent aux deux départements, occidental et central, du Guilan et du Mazendéran, mais dans le département oriental du Gorgan on trouve déjà un climat et des caractéristiques physiographiques se rapprochant de ceux du plateau. Il est nécessaire de mentionner ceci pour comprendre la distribution de certaines formes. Ainsi le *Metacyclops minutus*, Cyclopide prépondérant dans le Sud et qui se rencontre aussi sur le plateau, a été récolté à Gorgan (Astéradabad), capital du département de même nom, mais dans aucune localité du Mazendéran et du Guilan.

Une idée de l'abondance des diverses espèces récoltées peut s'obtenir du tableau détaillé des habitats se trouvant à la fin de ce travail, et la liste des 12 espèces les plus fréquentes, rangées dans l'ordre de leur abondance approximative qui a été indiquée par des croix, est donnée ci-dessous, accompagnés d'une note sommaire sur leur fréquence.

—	Abondance	Fréquence	Répartition principale
<i>Metacyclops minutus</i> ..	+ + +	Très fréquent	Sud.
<i>Acanthocyclops bicuspidatus</i>	+ +	Très fréquent	Provinces Caspiennes.
<i>Acanthocyclops bisetosus</i> ..	+ +	Très fréquent	Provinces Caspiennes.
<i>Cyclops strenuus divergens</i> ..	+ +	Très fréquent	Plateau.
<i>Thermocyclops rylovi</i> ..	+ +	Très fréquent	Sud.
<i>Thermocyclops vermifer</i> ..	+ +	Très fréquent	Sud.
<i>Eucyclops serrulatus</i> ..	+	Très fréquent	Sud. Plateau. Provinces Caspiennes.
<i>Megacyclops viridis</i> ..	+	Très fréquent	Provinces Caspiennes.
<i>Mesocyclops leuckarti</i> ..	+	Très fréquent	Sud.
<i>Acanthocyclops bicuspidatus odessanus</i> .	+	Fréquent	Sud.
<i>Microcyclops varicans</i> ..	Pas abondant	Assez fréquent	Sud. Plateau. Provinces Caspiennes.
<i>Metacyclops planus</i> ..	Pas abondant	Assez fréquent	Sud. Provinces Caspiennes.

Il a été question dans des articles antérieurs de conditions écologiques des formes étudiées et il doit suffir ici de faire quelques remarques générales à ce sujet. Je donne ci-dessous une liste des biotopes examinés dans lesquels des Cyclopides ont été trouvés. J'ai appelé *bassins* les pièces d'eau ayant en général plus de largeur que de profondeur, aménagées dans les jardins et les cours, de fonction ornementale ou servant à l'arrosage et aux ablutions, et d'habitude remplies par des canalisations souterraines ou de surface. Sous le nom de *réservoir* j'ai

désigné les constructions de maçonnerie à l'intérieur cimenté, le plus souvent de grandes dimensions, dans lesquelles on recueille l'eau de pluie, qu'on puise ensuite d'en haut. Par *citerne* j'entends ici des réservoirs plus petits, souvent munis de robinets et pouvant contenir, soit des eaux pluviales, soit de l'eau amenée par un conduit, ou retirée d'un puits du voisinage.

						Sud. Pla- teau. Est.	Provinces Caspennes.	Total.
Puits	..	..	..	..	..	35	6	41
Bassins (Haouz)	..	..	..	..	..	32	7	39
Réservoirs (Birkéh, ab-ambar)	..	..	..	..	..	24	..	24
Citernes (Ab-ambar)	..	..	..	..	..	12	..	12
Fosses	..	..	..	..	..	11	14	25
Mares	..	..	..	..	..	28	26	54
Étangs	..	..	..	..	..	26	5	31
Fleuves	..	..	..	..	..	2	..	2
Rivières, torrents, ruisseaux	..	..	..	..	..	6	6	2
Bras-morts de canaux d'irrigation	..	..	..	..	..	4	..	4
Rizières	..	..	..	..	..	..	3	3
Trous d'eau	..	..	..	..	..	..	2	2
Marécages	..	..	..	..	..	8	5	13
Mares de rivières et de torrents	..	..	..	..	..	16	2	18
Sources	..	..	..	..	..	2	..	2
Lagunes	..	..	..	..	..	1	2	3
Mousse d'une cascade	..	..	..	..	..	1	..	1

Les habitats du Sud et du plateau ont contenu aussi bien de l'eau douce que de l'eau saumâtre, dont le degré de salinité a naturellement varié. La plupart ont eu l'oligotrophie comme caractéristique commune. Dans le Nord j'ai pêché des *Cyclopides* dans des mares et des marais situés aux bords mêmes de la Caspienne et par conséquent faiblement salins, puisque la salinité de celle-ci est beaucoup moindre que celle des mers ouvertes. Autrement presque tous les habitats dans les provinces du Nord ont renfermé de l'eau douce et ont montré une végétation plus ou moins riche. Presque tous les rassemblements naturels d'eau de surface du Sud et du plateau ont été transitoires. Il est vrai qu'ils sont assez nombreux et abondants en hiver, qui est la saison pluvieuse, mais dès la fin de celle-ci l'eau des mares, des fosses et des étangs s'évapore et les marécages se dessèchent, de sorte qu'on ne trouve plus de l'eau que dans des puits, des réservoirs, des citernes, certains canaux d'irrigation et dans les quelques rares cours d'eau permanents. Dans les provinces Caspiennes par contre, du moins dans le Guilan et dans le Mazendéran, où la pluie tombe pendant toute l'année à peu près toutes les collections d'eau de surface sont permanentes.

Les *Cyclopides* étudiés ici ont été récoltés à des altitudes variant de 26 mètres au-dessous du niveau de la mer (côte Caspienne), à 1676 mètres au-dessus de ce niveau (Boroudjerd dans le Louristan). Je n'ai pas observé de préférence évidente tenant aux conditions orographiques. Cependant, il est possible que *Eucyclops rutneri elburziensis*, coloré richement en rouge et en bleu, soit une forme plutôt alpine. J'ai

eu l'impression que la faune des hautes montagnes en Iran doit être pauvre en Copépodes, du moins pendant la saison de l'année qu'a eu lieu ma dernière visite. Au cours d'une ascension faite en octobre du Totchal (au nord de Téhéran) dont l'altitude est de 3860 mètres, j'ai examiné la plupart des eaux rencontrées en route. Il y en a eu jusqu'à environ 200 mètres au-dessous du sommet, mais je n'ai trouvé aucun Copépode au-delà de Pasghaléh, à une altitude d'environ 1375 mètres.

La faune des Cyclopidés dans les régions visitées présente en somme les grandes lignes suivantes : Prédominance de *Megacyclops viridis*, d' *Acanthocyclops bicuspidatus* et d' *Acanthocyclops bisetosus* dans les eaux douces des provinces Caspiennes. Grande fréquence, de *Cyclops strenuus divergens* dans les bassins et les citernes du plateau, et fréquence probable aussi de *Thermocyclops tinctus* dans les biotopes similaires des régions désertiques de l'Est. Dans le Sud par contre, ce sont *Mesocyclops leuckarti*, *Thermocyclops rylovi* et *Thermocyclops vermifer* qui prévalent pendant toute l'année dans les habitats permanents, et en hiver c'est *Metacyclops minutus* qui est l'espèce prédominante, surtout dans les eaux de surface transitoires. Enfin, l'ubiquité d' *Eucyclops serrulatus* caractérise aussi bien l'Europe et l'Iran que l'Inde.

Quant à la classification biogéographique des 40 espèces identifiées il a été possible de les partager en 3 groupes seulement : celui des cosmopolites, des espèces arctiques et des formes tropicales, parmi lesquelles des animaux distribués surtout dans l'Asie centrale et dans le Proche Orient ont été inclus, par suite de leur parenté avec des espèces tropicales. J'ai tenu à ajouter pour chaque espèce l'indication de sa présence, certaine ou douteuse, ou de son absence dans l'Inde, y compris le Cachemire et le Ceylan, pour autant que cela soit connu à présent.

*A. Espèces plus ou moins cosmopolites : 9.*

				Inde		
				Présent.	Incertain.	Absent.
<i>Macrocyclops fuscus</i>	Jurine	..	..	—	—	+
<i>M. albidus</i>	Jurine	..	..	+	—	—
<i>Eucyclops serrulatus</i>	(Fischer)	..	..	+	—	—
<i>Tropocyclops prasinus</i>	(Fischer).	..	..	—	+	—
<i>Paracyclops fimbriatus</i>	(Fischer)	..	..	—	+	—
<i>Heterocyclops phaleratus</i>	(Koch)	..	..	—	+	—
<i>Microcyclops varicans</i>	Sars	..	..	+	—	—
<i>Mesocyclops leuckarti</i>	Claus	..	..	+	—	—
<i>Thermocyclops hyalinus</i>	(Rehberg)	..	..	+	—	—

*B. Espèces arctiques : 12.*

<i>Eucyclops macruroides</i> (Lilljeborg)	..	---	---	+
<i>Cyclops strenuus divergens</i> Lindberg.	..	---	---	+
<i>C. caspius</i> Lindberg	.. ..	---	---	+
<i>C. kozminskii</i> Lindberg	.. ..	---	---	+
<i>Megacyclops viridis</i> Jurine	.. ..	+	---	--
<i>Acanthocyclops vernalis</i> Fischer	..	---	---	+
<i>A. robustus</i> Sars.	.. ..	---	+	---
<i>A. bicuspidatus</i> Claus	.. ..	---	---	+
<i>A. bicuspidatus odessanus</i> Chmank.	..	---	---	+
<i>A. bisetosus</i> Rehbberg	.. ..	---	---	+
<i>Microcyclops bicolor</i> Sars	.. ..	---	---	---
<i>Thermocyclops dybowskii</i> Lande	..	---	---	+

*C. Espèces tropicales : 19.*

<i>Halicyclops thermophilus spinifer</i> Kiefer	+	---	---
<i>Eucyclops agiloides</i> Sars..	.. ..	+	---
<i>E. evacanthus</i> Sars	.. ..	+	---
<i>E. fursicus</i> Lindberg	.. ..	---	+
<i>E. rutneri elburziensis</i> Lindberg	..	---	+
<i>Tropocyclops confinis</i> Kiefer	.. ..	+	---
<i>Paracyclops vagus</i> Lindberg	.. ..	+	---
<i>Ectocyclops rubescens</i> Brady.	.. ..	+	---
<i>Microcyclops richardi</i> Lindberg	..	---	+
<i>M. moghulensis</i> Lindberg.	.. ..	+	-
<i>M. linjanticus</i> Kiefer	.. ..	+	-
<i>Metacyclops minutus</i> Claus	.. ..	+	---
<i>M. grandispinifer</i> Lindberg	.. ..	---	+
<i>M. planus</i> Gurney	.. ..	---	+
<i>Apocyclops degeizicus</i> Lepechkin	..	+	---
<i>Thermocyclops rylai</i> Smirnov	.. ..	---	+
<i>Th. microspinulosus</i> Lindberg.	..	---	+
<i>Th. vermifer</i> Lindberg	.. ..	+	---
<i>Th. tinctus</i> Lindberg	.. ..	+	---

En contemplant le groupement qui vient d'être donné on est aussitôt frappé par le grand nombre d'espèces tant arctiques que tropicales, récoltées ainsi dans un même pays. Abstraction faite des cosmopolites y a là 12 formes de l'Inde et presque autant de l'Europe. J'ignore si des faunes arctique et tropicale se recouvrent si complètement s'observent dans quelque autre pays du monde, mais il est évident que c'est bien l'Iran qui sert de point de rencontre pour ces deux branches du groupe d'animaux dont il s'agit ici. Ce n'est guère dans les provinces Caspiennes qu'a lieu ce rendez-vous, car les quelques formes tropicales qui s'y observent s'apparentent à des animaux de l'Asie centrale ou du Levant, qui sont déjà des proches parents d'espèces tropicales. Sur le plateau les faunes se recouvrent bien, mais c'est surtout dans le Sud, à été torride et hiver tempéré que vivent des formes arctiques côte à côte avec des espèces tropicales. Toutefois j'ai des raisons de croire que l'apparition des premières y est saisonnière, c'est-à-dire limitée à l'hiver, car je n'ai rencontré aucune de ces espèces dans le Sud pendant mon voyage en 1935, dont le début avait lieu pendant la saison chaude. Il semble aussi qu'on peut conclure à une adaptabilité plus grande chez les espèces arctiques que chez les formes tropicales.



## A. SUD (KHOUZISTAN ET LITTORAL DU GOLFE IRANIEN).

- APADAN.** Niveau de la mer.  
Fosse à l'eau oligotrophique dans plantation de dattiers. 16.1.40.  
*Megacyclops viridis* Jurine. Nombreux, surtout jeunes.
- ABADAN.** Niveau de la mer.  
Autre fosse semblable dans plantation de dattiers. 16.1.40.  
*Megacyclops viridis* Jurine. Nombreux, surtout jeunes.  
*Acanthocyclus bicuspidatus odessanus* Chmank. 1 ♂, 3 ♀♀.  
*Metacyclops planus* Gurney. 1 ♂.
- ABD IMAM.** Niveau de la mer, près Gue-navéh.  
Puits à l'eau saumâtre. 9.2.40.  
*Thermocyclus rylovi* Smirnov. Nom-breux.
- ABD IMAM.** Niveau de la mer, près Gue-navéh.  
Étang d'eau douce oligotrophique. 9.2.40.  
*Eucyclops serrulatus* (Fischer). 1 ♂.  
*Metacyclops minutus* Claus. 1 ♀.  
*Metacyclops planus* Gurney. 5 ♀♀, assez nombreux jeunes.  
*Apocyclus dengizicus* Lepchek. 1 ♂.  
*Thermocyclus rylovi* Smirnov. 7 ♂♂, 2 ♀♀, 9 jeunes.
- AHVAZ.** 24 m.  
Mare d'eau de pluie près du jardin potager municipal. 14.1.40.  
*Metacyclops minutus* Claus. Très nom-breux.
- AHVAZ.** 24 m.  
Citerne d'eau douce croupissante. 9.1.40.  
*Metacyclops minutus* Claus. Très nom-breux.
- AHVAZ.** 24 m.  
Marécage à végétation aquatique entre les deux voies ferrées, rive droite. 14.1.40.  
*Acanthocyclus bicuspidatus odessanus* Chmank. Assez nombreux.
- AHVAZ.** 24 m.  
Mare sans végétation près du pont, rive droite. 9.1.40.  
*Metacyclops minutus* Claus. Assez nom-breux.
- AHVAZ.** 24 m.  
Petite mare dans le jardin potager municipal, près du fleuve. 14.1.40.  
*Eucyclops serrulatus* (Fischer). 12 ♀♀.  
*Metacyclops minutus* Claus. 2 ♀♀.
- AHVAZ.** 24 m.  
Mare temporaire près de la distillerie, rive gauche. 18.1.40.  
*Metacyclops minutus* Claus. Très nom-breux.  
*Mesocyclus leuckarti* Claus. Quelques jeunes.
- AHVAZ.** 24 m.  
Petite mare près d'un canal d'irrigation. 20.1.40.  
*Eucyclops serrulatus* (Fischer). 3 ♀♀, 2 jeunes.
- AHVAZ.** 24 m.  
Petit étang dans un champ près des casernes. 14.1.40.  
*Acanthocyclus bicuspidatus odessanus* Chmank. Assez nombreux.
- AHVAZ.** 24 m.  
Marécage près de la voie ferrée, rive droite. 14.1.40.  
*Acanthocyclus bicuspidatus odessanus* Chmank. Plusieurs.  
*Metacyclops minutus* Claus. Peu nom-breux.
- AHVAZ.** 24 m.  
Bassin dans le jardin potager municipal. 14.1.40.  
*Mesocyclus leuckarti* Claus. Quelques jeunes.
- AHVAZ.** 24 m.  
Bassin dans un jardin près du Karoun, rive gauche. 18.1.40.  
*Eucyclops serrulatus* (Fischer). Quelques jeunes.  
*Mesocyclus leuckarti* Claus. 3 ♀♀.
- AHVAZ.** 24 m.  
Bassin du Jardin national. 9.1.40.  
*Mesocyclus leuckarti* Claus. Nombreux.
- AHVAZ.** 24 m.  
Bassin de l'Hôtel Iran. 9.1.40.  
*Mesocyclus leuckarti* Claus 2 ♂♂, 7 copépodites.  
*Thermocyclus vermifer* Lindberg. 8 ♂♂, 16 ♀♀, 26 copépodites.
- AHVAZ.** 24 m.  
Étang d'eau saumâtre près de la cimetière musulmane. 21.1.40.  
*Eucyclops serrulatus* (Fischer). 1 ♂, 1 jeune.  
*Acanthocyclus bicuspidatus odessanus* Chmank 1 ♂, 1 jeune.  
*Metacyclops grandispinifer* Lindberg. 1 ♀.  
*Apocyclus dengizicus* Lepchek. 1 ♂, 1 ♀.
- AKHTAR.** Niveau de la mer. Port du Dechty.  
Réservoir à ciel ouvert. 27.2.40.  
*Metacyclops minutus* Claus. Peu nom-breux, ♂♂ et jeunes.
- AKHTAR.** Niveau de la mer. Port du Dechty.  
Réservoir à ciel ouvert, à surface de l'eau couverte de Lemna. 27.2.40.  
*Metacyclops minutus* Claus. Assez nom-breux, surtout jeunes.
- AKHTAR.** Niveau de la mer. Port du Dechty.  
Puits à l'eau douce. 27.2.40.  
*Mesocyclus leuckarti* Claus. 3 ♀♀, plusieurs ♂♂.
- ANDIMÉCHK (Saléhabad).** Près Dizfoul.  
Mare d'eau de pluie oligotrophique. 12.1.40.  
*Metacyclops minutus* Claus. Peu nom-breux, surtout jeunes.  
*Thermocyclus* sp. 1 copépodite.

A. SUD (KHOUZISTAN ET LITTORAL DU GOLFE IRANIEN)—*contd.*

- ANDIMÈCHK (*Saléhabad*). Près Dizfoul.  
Mare d'eau de pluie semblable. 12.1.40.  
*Metacyclops minutus* Claus. Assez nombreux.
- ASSALOU. Niveau de la mer. Port du Dechty.  
Étang salin eutrophique, temporaire.  
*Metacyclops minutus* Claus. Quelques ♀♀ seulement.  
*Thermocyclops rylovi* Smirnov. Peu.
- ASSALOU. Niveau de la mer. Port du Dechty.  
Réservoir à dôme. 29.2.40.  
*Metacyclops minutus* Claus. Une vingtaine de ♀♀.  
*Thermocyclops vermifer* Lindberg. 1 ♀.
- ASSALOU. Niveau de la mer. Port du Dechty.  
Puits à l'eau douce. 29.2.40.  
*Metacyclops minutus* Claus. Très peu, 1 ♀, adulte.  
*Mesocyclops leuckarti* Claus. 1 ♂, 1 ♀.  
*Thermocyclops rylovi* Smirnov. 1 ♀.
- BENDER CHAHPOUR. Niveau de la mer.  
Mare à l'eau saumâtre. 20.1.40.  
*Eucyclops serrulatus* (Fischer). 1 ♀.  
*Metacyclops minutus* Claus. 1 ♀.  
*Mesocyclops leuckarti* Claus. 3 ♂♂, 2 ♀♀, 1 copépodite.
- BENDER CHAHPOUR. Niveau de la mer.  
Citerne d'eau douce. 20.1.40.  
*Eucyclops serrulatus* (Fischer). 5 ♂♂, 15 ♀♀, 1 copépodite.  
*Metacyclops minutus* Claus. 1 ♀.  
*Mesocyclops leuckarti* Claus. 11 ♂♂, 11 ♀♀, 11 copépodites.
- BENDER RIG. Niveau de la mer. Port du Dechtistan.  
Puits à l'eau saumâtre. 9.2.40.  
*Metacyclops minutus* Claus. Quelques jeunes.  
*Thermocyclops vermifer* Lindberg. 1 ♀.
- BÉTANÉH. Littoral du Dechty, à environ 12 km. au nord de Dayyir.  
Puits. 26.2.40.  
*Metacyclops minutus* Claus. 1 ♀, quelques jeunes.
- BIRIKOU. Littoral du Tanguistan, à environ 5 km. au nord de Lavar.  
Réservoir d'eau de pluie, à toit. 23.2.40.  
*Metacyclops minutus* Claus. Assez nombreux.  
*Mesocyclops leuckarti* Claus. Quelques.
- BIRKÉH TCHIPOU. Littoral du Dechty, à 12 km. au sud de Kangan.  
Réservoir d'eau de pluie, à ciel ouvert. 27.2.40.  
*Metacyclops minutus* Claus. Nombreux.
- BORAZDJAN. 76 m.  
Puits à l'eau légèrement saumâtre. 16.2.40.  
*Metacyclops grandispinifer* Lindberg. 1 ♂, 3 ♀♀.  
*Mesocyclops leuckarti* Claus. 1 ♂, 1 copépodite.
- BORAZDJAN. 76 m.  
Bassin du Jardin national. 16.2.40.  
*Mesocyclops leuckarti* Claus. 1 copépodite.
- BORAZDJAN. 76 m.  
Petit étang. 16.2.40.  
*Metacyclops minutus* Claus. Peu.
- BORD-KHOUN. Littoral du Dechty, au sud de Khour Ziarat.  
Petit étang à l'eau douce crouissante. 25.2.40.  
*Metacyclops minutus* Claus. Très nombreux.
- BOUCHIR. 1 m.  
Citerne à l'eau saumâtre près d'un puits. 16.2.40.  
*Thermocyclops microspinulosus* Lindberg. 1 ♂, 4 ♀♀, 2 jeunes.
- BOUCHIR. 1 m.  
Étang temporaire d'eau saumâtre. 16.2.40.  
*Metacyclops minutus* Claus. Peu.
- BOUCHIR. 1 m.  
Autre étang semblable. 16.2.40.  
*Metacyclops minutus* Claus. Peu.
- BOUCHIR. 1 m.  
Lagune. 18.2.40.  
*Metacyclops minutus* Claus. Peu.
- BOUCHIR. 1 m.  
Fosses à l'eau saumâtre sur la route à Tchaghadak. 16.2.40.  
*Acanthocyclops bicuspidatus odessanus* Chmank. 2 ♀♀.  
*Metacyclops minutus* Claus. Quelques.  
*Metacyclops grandispinifer* Lindberg. 2 ♀♀.  
*Metacyclops planus* Gurney. 1 ♀.
- BOULKHÉIR. Port du Tanguistan.  
Puits à l'eau douce. 22.2.40.  
*Mesocyclops leuckarti* Claus. 20 ♀♀, 4 copépodites.
- CHOUGH (SUSE).  
Maréage près de l'Imam Zadh Abbas. 11.1.40.  
*Metacyclops minutus* Claus. Peu.
- CHOUGH (SUSE).  
Fosse près de la gare. 11.1.40.  
*Eucyclops serrulatus* (Fischer). 4 ♂♂, 14 ♀♀, 2 jeunes.  
*Ectocyclops rubescens* Brady. 1 ♀.  
*Megacyclops viridis* Jurine. 1 ♀.  
*Microcyclops varicans* Sars. 2 ♀♀.  
*Metacyclops planus* Gurney. 1 ♀.
- CHOUGH (SUSE).  
Citerne près de la gare. 11.1.40.  
*Eucyclops serrulatus* (Fischer). 1 ♀.  
*Megacyclops viridis* Jurine. 1 ♀.  
*Microcyclops varicans* Sars. 1 ♀.  
*Mesocyclops leuckarti* Claus. 16 ♂♂, 15 ♀♀, 21 copépodites.

A. SUD (KHOUSTAN ET LITTORAL DU GOLFE IRANIEN)—*concl'd.*

## CHOUGH (Suse).

Marécage près du village. 11.1.40.

*Eucyclops serrulatus* (Fischer). 12 ♂♂,  
8 ♀♀, 13 copépodites.*Ectocyclops rubescens* Brady. 7 ♀♀,  
2 jeunes.*Megacyclops viridis* Jurine. 28 ♂♂,  
35 ♀♀, 85 jeunes.*Microcyclops varicans* Sars. 9 ♂♂, 23 ♀♀,  
15 copépodites.

## CHOUGHTER. 64 m.

Mare dans le lit de la rivière Mihaou  
(Miandoab). 23.1.40.*Eucyclops serrulatus* (Fischer). Nom-  
breux.*Metacyclops minutus* Claus. Assez nom-  
breux.

## CHOUGHTER. 64 m.

Rivière Minaou (Miandoab), au sud de la  
ville. 23.1.40.*Eucyclops serrulatus* (Fischer). Peu.*Paracyclops vagus* Lindberg. 3 ♀♀.*Cyclops strenuus divergens* Lindberg.  
1 ♀.DARQOIN. Environ 33 km. au nord de  
Khorramchahr.

Fosse. 17.1.40.

*Paracyclops fimbriatus* (Fischer). 1 ♀.*Acanthocyclops bicuspidatus odessanus*  
Chamank 1 ♀.*Metacyclops minutus* Claus. 1 ♂, 1 jeune.*Mesocyclops leuckarti* Claus. 4 copé-  
podites.DAYIR. Niveau de la mer. Port du  
Dechty.

Puits à l'eau saumâtre. 26.2.40.

*Mesocyclops leuckarti* Claus. 1 ♂, 1 ♀.*Thermocyclops rylovi* Smirnov. Nom-  
breux.

## DILVAR. Littoral du Tanguistan.

Réservoir d'eau douce, à toit. 21.2.40.

*Metacyclops minutus* Claus. Peu.

## DILVAR. Littoral du Tanguistan.

Puits à l'eau saumâtre. 21.2.40.

*Thermocyclops vermifer* Lindberg. 2 ♀♀.

## DIZFOUL. 149 m.

Mare temporaire. 12.1.40.

*Metacyclops minutus* Claus. Quelques.

## DIZFOUL. 149 m.

Mare souterraine dans le roc. 12.1.40.

*Paracyclops fimbriatus* (Fischer). 1 ♂,  
1 ♀.

## DIZFOUL. 149.

Mare temporaire. 12.1.40.

*Metacyclops minutus* Claus. Quelques.

## DIZFOUL. 149 m.

Mare temporaire à l'eau saumâtre. 12.1.40.

*Metacyclops minutus* Claus. Peu.*Metacyclops planus* Gurney. 1 ♂.

## DIZFOUL. 149 m.

Mare temporaire. 12.1.40.

*Metacyclops minutus* Claus. 2 ♂♂, 5 ♀♀.*Metacyclops planus* Gurney. 1 ♀.

## DOMAGAZ (DAMÈH GAZ). Port du Dechty.

Puits à l'eau saumâtre. 26.2.40.

*Metacyclops minutus*. Quelques.GANI. Littoral du Tanguistan, à 3 km. au  
nord de Boulkhéir.

Puits à l'eau saumâtre. 22.2.40.

*Mesocyclops leuckarti* Claus. Quelques.GORGOR. Sur le Djerrahi, à 62 km. au sud  
d'Ahvaz.

Marais près de la voie ferrée. 20.1.40.

*Metacyclops minutus* Claus. Nombreux  
♂♂ et copépodites.

## GUÉNAVÉH. Port du Dechtistan.

Mare d'eau saumâtre. 9.2.40.

*Metacyclops minutus* Claus. Quelques.*Apocyclops dengizicus* Lepechck. 1 ♂.*Thermocyclops rylovi* Smirnov. 1 ♂, 3 ♀♀.

## HADAKOU. Littoral du Tanguistan.

Puits à l'eau douce. 23.2.40.

*Metacyclops minutus* Claus. 4 ♂♂, 9 ♀♀.*Mesocyclops leuckarti* Claus. 24 ♂♂, 6 ♀♀,  
79 copépodites.*Thermocyclops rylovi* Smirnov. 4 ♂♂,  
9 ♀♀.

## HADAKOU. Littoral du Tanguistan.

Etang d'eau douce dans plantation de  
dattiers. 23.2.40.*Metacyclops minutus* Claus. Quelques  
♀♀ adultes, et assez nombreux jeunes.

## KANGAN (KANGOUN). Port du Dechty.

Puits à l'eau saumâtre. 27.2.40.

*Metacyclops minutus* Claus. Quelques.

## KARRI. Port du Tanguistan.

Puits à l'eau douce. 23.2.40.

*Mesocyclops leuckarti* Claus. Une ving-  
taine.KHALFABAD. Sur le Djerrahi, à 76 km. au  
sud-est d'Ahvaz.

Petite mare sans végétation. 30.1.40.

*Metacyclops minutus* Claus. Très nom-  
breux.KHALFABAD. Sur le Djerrahi, à 76 km. au  
sud-est d'Ahvaz.Petit étang sans végétation (lieu de lavage).  
30.1.40.*Metacyclops minutus* Claus. Extrême-  
ment nombreux, surtout ♂♂ et copé-  
podites.

## KHORRAMCHAHK. 8 m.

Ruissau bourbeux. 12.9.35.

*Eucyclops serrulatus* (Fischer). 4 ♀♀.*Mesocyclops leuckarti* Claus. Quelques  
♀♀ et jeunes.*Thermocyclops rylovi* Smirnov. 2 ♂♂,  
quelques ♀♀.

## KHORRAMCHAHK. 8 m.

Fleuve Karoun, près du Chatt-el-Arab.  
12.9.35.*Mesocyclops leuckarti* Claus. Quelques  
♀♀.

A. SUD (KHOUZISTAN ET LITTORAL DU GOLFE IRANIEN)—*contd.*

- KHORRAMCHAHN.** 8 m.  
Petit marécage. 17.1.40.  
*Cyclops strenuus divergens* Lindberg.  
Quelques ♂♂, 6 ♀♀.  
*Acanthocyclops bicuspidatus odessanus*  
Chmank. Quelques ♀♀ et jeunes.  
*Microcyclops varicans* Sars. 1 ♂.  
*Metacyclops planus* Gurney. 6 ♂♂, 4 ♀♀.
- KHORRAMCHAHN.** 8 m.  
Bras-morts de canaux d'irrigation dans  
plantation de dattiers. 16.1.40.  
*Cyclops strenuus divergens* Lindberg.  
6 ♀♀.  
*Acanthocyclops bicuspidatus* Claus. 1 ♀.  
*Acanthocyclops bistotus* Rehb. 4 ♀♀.  
*Metacyclops planus* Gurney. 1 ♀, quel-  
ques jeunes.
- KHORRAMCHAHN.** 8 m.  
Fosse. 16.1.40.  
*Cyclops strenuus divergens* Lindberg.  
Quelques ♀♀ et jeunes.
- KHORRAMCHAHN.** 8 m.  
Fosse. 16.1.40.  
*Eucyclops serrulatus* (Fischer). 2 ♀♀,  
1 copépodite.  
*Megacyclops viridis* Jurine. 10 ♂♂,  
12 copépodites.  
*Metacyclops planus* Gurney. 1 ♂, 1 ♀.
- KHORRAMCHAHN.** 8 m.  
Bras-mort de canal d'irrigation de planta-  
tion de dattiers. 16.1.40.  
*Cyclops strenuus divergens* Lindberg.  
Plusieurs.  
*Megacyclops viridis* Jurine. 2 ♀♀.  
*Mesocyclops leuckarti* Claus. 1 ♀.
- KHORRAMCHAHN.** 8 m.  
Bras-mort de canal d'irrigation, côté  
Karoun. 17.1.40.  
*Cyclops strenuus divergens* Lindberg.  
Plusieurs.
- KHORRAMCHAHN.** 8 m.  
Petite mare. 17.1.40.  
*Cyclops strenuus divergens* Lindberg.  
1 ♂.  
*Megacyclops viridis* Jurine. 1 ♀.  
*Acanthocyclops bicuspidatus* Claus. 1 ♀.  
*Metacyclops planus* Gurney. 1 ♀.
- KORDOU.** Littoral du Dechty, à environ  
6 km. au nord de Khouz Ziarat.  
Puits à l'eau douce dans plantation de  
dattiers. 25.2.40.  
*Metacyclops minutus* Claus. Nombreux.
- LINGUÉH.** Niveau de la mer.  
Puits à l'eau saumâtre. 21.10.35.  
*Thermocyclops vermifer* Lindberg. Quel-  
ques ♀♀.
- MANSOURI.** 52 km. au sud d'Ahvaz.  
Etang oligotrophique. 20.1.40.  
*Metacyclops minutus* Claus. Quelques.
- MARGHAZAR.** 88-5 km. au sud d'Ahvaz.  
Fosse près de la gare. 20.1.40.  
*Eucyclops serrulatus* (Fischer). 1 ♀.  
*Acanthocyclops bicuspidatus odessanus*  
Chmank. 1 ♀.  
*Metacyclops minutus* Claus. 1 ♀.  
*Cyclops* sp. Copépodites 3, non identi-  
fiés.
- MIAN DACHT.** 16 km. au sud d'Ahvaz.  
Mares entre la gare de Karoun et celle de  
Mian Dacht. 21.1.40.  
*Metacyclops minutus* Claus. Assez nom-  
breux.  
*Metacyclops planus* Gurney. 1 ♀.
- MIAN DACHT.** 16 km. au sud d'Ahvaz.  
Marais près de la voie ferrée. 21.1.40.  
*Metacyclops minutus* Claus. Plusieurs.  
*Metacyclops planus* Gurney. 1 ♀, quel-  
ques copépodites.
- NAKHL TAQI.** Littoral du Dechty.  
Etang d'eau douce crouissante sans  
végétation. 29.2.40.  
*Thermocyclops rylovi* Smirnov. Extrême-  
ment nombreux.
- NAKHL TAQI.** Littoral du Dechty.  
Etang d'eau saumâtre, à l'eau assez propre,  
à végétation aquatique. 29.2.40.  
*Thermocyclops rylovi* Smirnov. Peu.
- NEREKOUH.** Littoral du Dechty, à environ  
36 km. au sud de Lavar.  
Puits à l'eau saumâtre. 25.2.40.  
*Metacyclops minutus* Claus. Quelques  
♂♂ et copépodites.
- OULI (ALI).** Littoral du Dechty, à 3 km.  
au nord de Dayyir.  
Puits. 26.2.40.  
*Mesocyclops leuckarti* Claus. Plusieurs.  
*Thermocyclops vermifer* Lindberg. Quel-  
ques.
- PARAK.** Littoral du Dechty, sud-est de  
Tahiri.  
Etang salin à 2 km. au sud du village.  
28.2.40.  
*Halicyclops thermophilus spinifer* Kiefer.  
6 ♀♀.  
*Metacyclops minutus* Claus. 3 ♂♂, 5 ♀♀,  
5 copépodites.  
*Metacyclops grandispinifer* Lindberg.  
1 ♀.  
*Thermocyclops vermifer* Lindberg. 3 ♂♂,  
3 copépodites.
- PARAK.** Littoral du Dechty, sud-est de  
Tahiri.  
Mare d'eau crouissante. 28.2.40.  
*Metacyclops minutus* Claus. Très nom-  
breux.  
*Thermocyclops vermifer* Lindberg. 1 ♀.

A. SUD (KHOUZISTAN ET LITTORAL DU GOLFE IRANIEN)—*concl'd.*

PORTÉH. Littoral du Dechty, sud-est de Tahiri.

Puits à l'eau douce. 28.2.40.

*Mesocyclops leuckarti* Claus. Quelques.  
*Thermocyclops vermifer* Lindberg. Une centaine.

RÉCHIR. 11 km. de Bouchir.

Puits à l'eau douce. 13.2.40.

*Microcyclops linjanticus* Kiefer. 8 ♀♀.  
*Mesocyclops leuckarti* Claus. 1 ♀, 5 copépodites.  
*Thermocyclops vermifer* Lindberg. 1 ♂, quelques ♀♀ et jeunes.

RÉCHIR. 13 km. de Bouchir.

Mare de rivière près de Paitell. 14.2.40.

*Metacyclops grandispinifer* Lindberg. 5 ♂♂, 3 ♀♀, 17 copépodites.  
*Thermocyclops rylovi* Smirnov. 2 ♂♂, 2 ♀♀.

TADJOMELKEH. Littoral du Dechtistan, au pied des monts Mahour, au nord-est de Guenavéh.

Puits à l'eau saumâtre. 8.2.40.

*Thermocyclops rylovi* Smirnov. 4 ♂♂, 15 ♀♀, 10 copépodites.

TAHIRI. Port du Dechty.

Puits à l'eau douce. 28.2.40.

*Thermocyclops vermifer* Lindberg. Quelques ♂♂, jeunes, 4 ♀♀, nombreux copépodites.

TAHIRI. Port du Dechty.

Mare d'eau douce grouillante. 28.2.40.

*Metacyclops minutus* Claus. 19 ♂♂, 24 ♀♀.  
*Thermocyclops vermifer* Lindberg. 3 ♂♂, 1 ♀, 22 copépodites.

## B. PLATEAU, MONTAGNES DU SUD, NORD-EST.

AHMEDABAD (DINGAR). Environ 800 m. 50 km. au sud de Firouzabad.

Petit étang temporaire d'eau de pluie oligotrophique. 3.3.40.

*Metacyclops minutus* Claus. Très nombreux.

BABA HADJI. 1463 m. 30 km. au sud de Chiraz.

Étang permanent d'eau douce eutrophique. 11.3.40.

*Macrocylops albidus* Jurine. 3 ♀♀.  
*Eucyclops euacanthus* Sars. 1 ♀.  
*Eucyclops farsicus* Lindberg. Assez nombreux.

*Tropocyclops confinis* Kiefer. Plusieurs.  
*Paracyclops vugus* Lindberg. 1 ♀.

*Ectocyclops phaleratus* (Koch). 1 ♀, 1 jeune.

*Microcyclops linjanticus* Kiefer. 1 ♀.

BAQIRABAD. 32 km. au nord de Qoum.

Petit étang d'eau douce. 17.3.40.

*Acanthocyclops bisetosus* Rehberg. 1 ♀.

TAHIRI. Port du Dechty.

Puits à l'eau douce entre Tahiri et Nakhli Taqi. 28.2.40.

*Mesocyclops leuckarti* Claus. 2 ♂♂, environ 75 ♀♀, beaucoup à sacs ovigères.  
*Thermocyclops vermifer* Lindberg. 2 ♂♂, 1 copépodite.

TAHIRI. Port du Dechty.

Réservoir à toit. 28.2.40.

*Mesocyclops leuckarti* Claus. Peu.  
*Thermocyclops vermifer* Lindberg. Peu.

TAHIRI. Port du Dechty.

Réservoir délabré sans toit, à l'eau couverte de Lemna. 28.2.40.

*Thermocyclops vermifer* Lindberg. Très nombreux.

TCHABADI. Environ 5 km. au sud de Hadakon.

Marais d'eau douce. 23.2.40.

*Acanthocyclops bisetosus* Rehberg. 1 ♀.  
*Microcyclops varicans* Sars. 1 ♀.  
*Metacyclops minutus* Claus. Très nombreux, surtout jeunes.  
*Mesocyclops leuckarti* Claus. Quelques jeunes.

*Thermocyclops vermifer* Lindberg. 1 ♀.

TCHAGHADAK. 24 km. à l'est de Bouchir.

Petit étang d'eau grouillante dans le village. 18.2.40.

*Metacyclops minutus* Claus. Assez nombreux.

TCHAGHADAK. 24 km. à l'est de Bouchir.

Fosse à 1 km. du village. 18.2.40.

*Acanthocyclops bicuspidatus odessanus* Chmank. Plusieurs.

*Metacyclops grandispinifer* Lindberg. 1 ♀.

ZIRHAK. Littoral du Tanguistan.

Puits à l'eau douce. 23.2.40.

*Metacyclops minutus* Claus. 3 ♀♀.

*Mesocyclops leuckarti* Claus. Quelques.

*Thermocyclops tinctus* Lindberg. 1 ♀.

BÉHRÉHAN. 396 m.

Puits à l'eau saumâtre. 4.2.40.

*Metacyclops minutus* Claus. 1 ♂.

*Mesocyclops leuckarti* Claus. 1 ♂, 1 ♀.

*Thermocyclops vermifer* Lindberg. 3 ♀♀.

BÉHRÉHAN. 396 m.

Réservoir à ciel ouvert. 2.2.40.

*Metacyclops minutus* Claus. Nombreux.

BÉHRÉHAN. 396 m.

Fosse d'eau de pluie à 3 km. à l'ouest de la ville. 1.2.40.

*Metacyclops minutus* Claus. Peu nombreux.

BÉHRÉHAN. 396 m.

Réservoir à ciel ouvert. 2.2.40.

*Metacyclops minutus* Claus. Quelques jeunes.

*Mesocyclops leuckarti* Claus. 1 ♀, 1 jeune.

BÉHRÉHAN. 396 m.

Petite rivière temporaire. 3.2.40.

*Eucyclops serrulatus* (Fischer). 4 ♂♂, 9 ♀♀.

*Metacyclops minutus* Claus. 2 ♂♂.

B. PLATEAU, MONTAGNES DU SUD, NORD-EST—*contd.*

- BÉHÉBÉHAN. 396 m.**  
Bassin de l'Hôpital municipal. 3.2.40.  
*Eucyclops serrulatus* (Fischer). Plusieurs, surtout jeunes.
- BÉHÉBÉHAN. 396 m.**  
Puits à l'eau saumâtre dans les champs. 2.2.40.  
*Eucyclops serrulatus* (Fischer). 1 ♂.  
*Acanthocyclops bicuspidatus* Claus. 1 ♂.  
*Metacyclops minutus* Claus. 4 ♂♂, 3 ♀♀, 8 copépodites.  
*Mesocyclops leuckarti* Claus. 5 jeunes.
- BÉHÉBÉHAN. 396 m.**  
Réservoir à ciel ouvert. 4.2.40.  
*Metacyclops minutus* Claus. Très nombreux, jeunes.
- BÉHÉBÉHAN. 396 m.**  
Petite citerne d'eau de puits saumâtre près de l'Imam Zadéh Bachir-un-Nasir. 4.2.40.  
*Eucyclops serrulatus* (Fischer). 2 ♂♂.  
*Microcyclops varicans* Sars. 1 ♀.  
*Metacyclops minutus* Claus. 8 ♂♂, 2 ♀♀, 8 copépodites.  
*Mesocyclops leuckarti* Claus. 1 ♂, 1 ♀, 7 jeunes.  
*Thermocyclops vermifer* Lindberg. 1 ♂, 15 ♀♀.
- BÉHÉBÉHAN. 396 m.**  
Réservoir d'eau de pluie à ciel ouvert, près de l'Imam Zadéh Bachir-un-Nasir. 4.2.40.  
*Metacyclops minutus* Claus. Très nombreux.
- BÉHÉBÉHAN. 396 m.**  
Bassin du Jardin national. 2.2.40.  
*Eucyclops serrulatus* (Fischer). 130 ♂♂, 78 ♀♀, très nombreux copépodites.  
*Metacyclops minutus* Claus. 1 ♂, 1 jeune.  
*Mesocyclops leuckarti* Claus. 7 ♂♂, 7 ♀♀, 12 copépodites.  
*Thermocyclops vermifer* Lindberg. 1 ♂, 6 ♀♀, 2 jeunes.
- BÉHÉBÉHAN. 396 m.**  
Petit étang temporaire d'eau de pluie. 2.2.40.  
*Metacyclops minutus* Claus. Nombreux.
- BÉHÉBÉHAN. 396 m.**  
Marc de rivière temporaire à l'eau saumâtre, sans végétation. 2.2.40.  
*Eucyclops serrulatus* (Fischer). Plusieurs ♂♂, Quelques ♀♀.
- BÉHÉBÉHAN. 396 m.**  
Réservoir souterrain voûté. 2.2.40.  
*Eucyclops serrulatus* (Fischer). Nombreux.  
*Microcyclops moghulensis* Lindberg. 1 ♀.  
*Mesocyclops leuckarti* Claus. 3 jeunes.
- BÉHÉBÉHAN. Environ 500 m.**  
Petit étang d'eau douce dans les montagnes à 24 km. de la ville. 1.2.40.  
*Metacyclops minutus* Claus. 2 ♀♀.  
*Metacyclops grandispinifer* Lindberg. 2 ♀♀.  
*Thermocyclops tinctus* Lindberg. Plusieurs.
- BÉHÉBÉHAN. Environ 450 m.**  
Marc de rivière dans les montagnes à environ 20 km. au sud-ouest de la ville. 1.2.40.  
*Metacyclops grandispinifer* Lindberg. 1 ♀, plusieurs jeunes.  
*Thermocyclops tinctus* Lindberg. Quelques.
- BOROUJERD. 1676 m.**  
Etang eutrophique d'eau douce. 19.9.35.  
*Eucyclops serrulatus* (Fischer). Quelques ♀♀.  
*Megacyclops viridis* Jurine. Quelques ♂♂, assez nombreuses ♀♀.
- BOROUJERD. 1667 m.**  
Citerne à l'eau douce. 19.9.35.  
*Cyclops strenuus divergens* Lindberg. Très nombreux.  
*Thermocyclops dybowskii* Lande. Nombreux.
- BOROUJERD. 1676 m.**  
Autre citerne à l'eau douce. 19.9.35.  
*Cyclops strenuus divergens* Lindberg. Nombreux jeunes.
- BOURM. Environ 1000 m.** Au sud de Galléhdar entre Fal et Dilou.  
Source d'eau douce. 1.3.40.  
*Eucyclops serrulatus* (Fischer). Plusieurs  
*Ectocyclops rubescens* Brady. 1 ♀, 1 copépodite.
- BOURM. Environ 900 m.** Entre Bourm et Fal.  
Marc de rivière à l'eau douce. 1.3.40.  
*Tropocyclops confinis* Kiefer. Quelques ♀♀.
- CHAH ABDOL AZIM. 1015 m.** Au sud de Téhéran.  
Bassin du sanctuaire. 16.11.39.  
*Cyclops strenuus divergens* Lindberg. Quelques.
- CHAHROUD. 1385 m.**  
Bassin d'un caravansérail. 28.11.39.  
*Eucyclops serrulatus* (Fischer). Assez nombreux.
- CHAHROUD. 1385 m.**  
Bassin de la Banque Mellic. 28.11.39.  
*Eucyclops serrulatus* (Fischer). Nombreux.
- CHAHROUD. 1385 m.**  
Petite mare à fond de feuilles décomposées. 28.11.39.  
*Eucyclops serrulatus* (Fischer). Nombreux.

## B. PLATEAU, MONTAGNES DU SUD, NORD-EST—contd.

- CHAHROUD. 1385 m.  
Mare près d'un canal d'irrigation.  
28.11.30.  
*Eucyclops serrulatus* (Fischer). Très nombreux.
- CHAHROUD. 1385 m.  
Autre mare près d'un canal d'irrigation.  
28.11.30.  
*Eucyclops serrulatus* (Fischer). Nombreux.
- CHIRAZ. 1585 m.  
Puits à l'eau saumâtre. 7.10.35.  
*Eucyclops serrulatus* (Fischer). Peu.
- CHIRAZ. 1585 m.  
Autre puits à l'eau saumâtre. 7.10.35.  
*Eucyclops serrulatus* (Fischer). Peu.  
*Cyclops strenuus divergens* Lindberg. Quelques.
- CHIRAZ. 1585 m.  
Citerne souterraine du tombeau de Haïez.  
6.10.35.  
*Cyclops strenuus divergens* Lindberg. Plusieurs ♂♂ et ♀♀.
- CHIRAZ. 1585 m.  
Bassin près du tombeau de Hafez. 14.3.40.  
*Cyclops strenuus divergens* Lindberg. Une vingtaine.
- CHIRAZ. 158 m.  
Autre bassin près du tombeau de Hafez. 14.3.40.  
*Megacyclops viridis* Jurine. 1 ♂, 1 jeune.
- CHIRAZ. 1585 m.  
Bassin d'un jardin. 14.3.40.  
*Eucyclops serrulatus* (Fischer). 1 ♀.  
*Cyclops strenuus divergens* Lindberg. 1 ♂, 1 ♀, 2 jeunes.  
*Megacyclops viridis* Jurine. 2 jeunes.
- DAR-OL-MIZAN. 365 m. Au nord-est de Djam.  
Réservoir à ciel ouvert. 3.3.40.  
*Metacyclops minutus* Claus. Une vingtaine.  
*Mesocyclops leuckarti* Claus. 1 ♀.
- DERBEND (CHEMIRAN). Environ 1350 m.  
Mare d'un torrent. 13.10.39.  
*Eucyclops ruttneri elburziensis* Lindberg. Quelques.
- DERBEND (CHEMIRAN). Environ 1350 m.  
Mare d'un torrent. 13.10.39.  
*Eucyclops ruttneri elburziensis* Lindberg. Plusieurs.
- DERBEND (CHEMIRAN). Environ 1350 m.  
Mare d'un torrent. 17.10.39.  
*Eucyclops ruttneri elburziensis* Lindberg. Plusieurs.  
*Acanthocyclops bicuspidatus* Claus. Quelques.
- DIHAK. Environ 800 m. Entre Dar-ol-Mizan et Kourdék.  
Source d'eau douce. 4.3.40.  
*Microcyclops varicans* Sars. Quelques ♀♀.  
*Microcyclops linjanticus* Kiefer. 1 ♀.
- DILOU. Environ 1200 m. Entre Assalou et Bourm.  
Réservoir d'eau douce à ciel ouvert. 1.3.40.  
*Metacyclops minutus* Claus. Quelques.
- DJAM. 548 m.  
Puits à l'eau douce. 3.3.40.  
*Mesocyclops leuckarti* Claus. Quelques.
- DJAM. 548 m.  
Citerne naturelle dans le roc sur la route vers Makkou. 3.3.40.  
*Thermocyclops tinctus* Lindberg. 43 ♂♂, 8 ♀♀, 71 copépodites.
- DJAM. 548 m.  
Mares de rivière sur la route vers Makkou. 3.3.40.  
*Eucyclops serrulatus* (Fischer). 7 ♂♂, 6 ♀♀.  
*Tropocyclops confinis* Kiefer. 2 ♂♂, 3 ♀♀.  
*Microcyclops linjanticus* Kiefer. 1 ♀.  
*Mesocyclops leuckarti* Claus. 2 ♀♀, 1 copépodite.
- DJAVAKAN (DJAVAKOU). Environ 1200 m. Environ 33 km. au nord de Firouzabad.  
Mare près d'un ruisseau à végétation émergente. 10.3.40.  
*Eucyclops serrulatus* (Fischer). 30 ♂♂, 46 ♀♀, 55 copépodites.
- FIROUZABAD.  
Bassin. 10.3.40.  
*Eucyclops serrulatus* (Fischer). 1 ♂, 6 ♀♀, 3 copépodites.  
*Megacyclops viridis* Jurine. 2 ♀♀.  
*Mesocyclops leuckarti* Claus. 1 ♂, 3 ♀♀, 2 copépodites.
- GALLÉHDAR.  
Réservoir à la surface de l'eau couverte de Lemna. 2.3.40.  
*Metacyclops minutus* Claus. Très peu.
- GALLÉHDAR.  
Réservoir à l'eau sans Lemna. 2.3.40.  
*Metacyclops minutus* Claus. Très nombreux, surtout ♂♂.
- GALLÉHDAR.  
Réservoir à l'eau sans Lemna. 2.3.40.  
*Metacyclops minutus* Claus. 1 ♂.  
*Thermocyclops cernifer* Lindberg. Assez nombreux.
- GATCH SARAN. Dans les montagnes du Kouglouyéh, à environ 70 km. au sud-est de Béhéhan.  
Mare près d'un torrent d'eau douce. 5.2.40.  
*Eucyclops serrulatus* (Fischer). 1 ♀.  
*Metacyclops minutus* Claus. Quelques.  
*Metacyclops grandispinifer* Lindberg. Plusieurs.
- ISFAHAN. 1616 m.  
Puits à l'eau douce. 1.10.35.  
*Cyclops strenuus divergens* Lindberg. Plusieurs.

B. PLATEAU, MONTAGNES DU SUD, NORD-EST—*contd.*

- ISFAHAN. 1616 m.  
Autre puits à l'eau douce. 1.10.35.  
*Cyclops strenuus divergens* Lindberg. Quelques.
- ISFAHAN. 1616 m.  
Etang d'eau douce. 30.9.35.  
*Eucyclops serrulatus* (Fischer). 2 jeunes.  
*Paracyclops fimbriatus* (Fischer). 1 ♀.
- ISFAHAN. 1616 m.  
Petit étang près d'un ruisseau. 16.3.40.  
*Eucyclops serrulatus* (Fischer). Quelques.
- ISFAHAN. 1616 m.  
Bassin de l'Hôtel Tchahar Bagh. 16.3.40.  
*Eucyclops serrulatus* (Fischer) ? (Atypique). 2 ♂♂, 2 ♀♀.  
*Thermocyclops rylovi* Smirnov. 1 ♀.
- ISFAHAN. 1616 m.  
Puits. 16.3.40.  
*Paracyclops fimbriatus* (Fischer). 3 ♀♀, 1 jeune.  
*Megacyclops viridis* Jurine. 2 ♂♂, 2 ♀♀, 10 jeunes.  
*Thermocyclops* sp. 1 copépodite.
- KEREDJ. 1262 m.  
Maré à feuilles décomposées. 1.1.40.  
*Eucyclops serrulatus* (Fischer). Très nombreux.  
*Cyclops strenuus divergens* Lindberg. 1 ♀.
- KEREDJ. 1262 m.  
Petite mare eutrophique. 1.1.40.  
*Eucyclops serrulatus* (Fischer). Nombreux.  
*Eucyclops ruttneri elburziensis* Lindberg. 1 ♀.  
*Megacyclops viridis* Jurine. 4 ♀♀, 1 jeune.
- KEREDJ. 1262 m.  
Mare de rivière à l'eau remplie d'algues. 1.1.40.  
*Eucyclops serrulatus* (Fischer). Plusieurs.
- KEREDJ. 1262 m.  
Autre mare de rivière semblable. 1.1.40.  
*Eucyclops serrulatus* (Fischer). Plusieurs.
- KEREDJ. 1262 m.  
Mare à végétation émergente. 1.1.40.  
*Eucyclops serrulatus* (Fischer). Très nombreux.
- KHORAB. Environ 38 km. au sud de Firouzabad.  
Rivière à l'eau saumâtre bordée de végétation. 6.3.40.  
*Eucyclops euacanthus* Sars. 3 ♂♂.  
*Ectocyclops rubescens* Brady. 2 ♀♀.  
*Metacyclops minutus* Claus. 1 ♀.  
*Mesocyclops leuckarti* Claus. 1 ♂.
- KOURDÉH. 305 m. A 30 km. au sud-est de Dizgah.  
Puits à l'eau saumâtre. 4.3.40.  
*Mesocyclops leuckarti* Claus. 3 ♂♂, 1 ♀, quelques copépodites.
- LAR. Environ 900 m.  
Réservoir. 13.10.35.  
*Mesocyclops leuckarti* Claus. Quelques.
- LAR. Environ 900 m.  
Autre réservoir. 13.10.35.  
*Mesocyclops leuckarti* Claus. Peu.
- LAR. Environ 900 m.  
Autre réservoir. 15.10.35.  
*Mesocyclops leuckarti* Claus. Peu.
- LAR. Environ 900 m.  
Bassin à l'eau saumâtre d'une mosquée. 15.10.35.  
*Mesocyclops leuckarti* Claus. Extrêmement nombreux.
- LAR. Environ 900 m.  
Bassin à l'eau saumâtre d'une canalisation. 15.10.35.  
*Mesocyclops leuckarti* Claus. Nombreux.
- LAR. Environ 900 m.  
Puits à l'eau saumâtre. 15.10.35.  
*Mesocyclops leuckarti* Claus. Quelques.
- LAR. Environ 900 m.  
Autre puits à l'eau saumâtre. 15.10.35.  
*Mesocyclops leuckarti* Claus. Quelques.
- MAKKOU. Environ 7 km. au nord-est de Djam.  
Réservoir d'eau douce, voûté. 3.3.40.  
*Metacyclops minutus* Claus. Une centaine de ♂♂ et de copépodites, 7 ♀♀ adultes.  
*Thermocyclops tinctus* Lindberg. Quelques ♀♀.
- MANSOURIYÉH. Environ 396 m. 6 km. de Béhéhan.  
Petit étang. 3.2.40.  
*Metacyclops minutus* Claus. Peu. Quelques ♀♀ adultes.
- MANSOURIYÉH. Environ 396 m. 6 km. de Béhéhan.  
Petite mare. 3.2.40.  
*Metacyclops minutus* Claus. Nombreux.
- MANSOURIYÉH. Environ 396 m. 6 km. de Béhéhan.  
Fosse dans plantation de dattiers. 3.2.40.  
*Metacyclops minutus* Claus. Nombreux.
- MANSOURIYÉH. Environ 396 m. 6 km. de Béhéhan.  
Réservoir d'eau douce, à toit délabré. 3.2.40.  
*Metacyclops minutus* Claus. Très nombreux.
- MANSOURIYÉH. Environ 396 m. 9 km. de Béhéhan.  
Petit étang près des montagnes. 3.2.40.  
*Metacyclops minutus* Claus. Nombreux.
- MANSOURIYÉH. Environ 396 m. 6 km. de Béhéhan.  
Mare à surface couverte d'algues vertes. 3.2.40.  
*Eucyclops serrulatus* (Fischer). 1 ♀.  
*Tropocyclops prasinus* (Fischer). 1 ♀.  
*Metacyclops minutus* Claus. Assez nombreux.  
*Metacyclops planus* Gurney. Plusieurs.



B. PLATEAU, MONTAGNES DU SUD, NORD-EST—*contd.*

- MÉCHHED.** 930 m.  
Bassin du Jardin national. 8.11.35.  
*Macrocyclus albidus* Jurine. 2 ♂♂, 5 ♀♀.  
*Eucyclops serrulatus* (Fischer). Quelques.
- MÉCHHED.** 930 m.  
Bassin de l'Hôtel de Paris. 8.11.35.  
*Eucyclops serrulatus* (Fischer). Quelques ♀♀.
- MÉCHHED.** 930 m.  
Bassin d'un jardin privé. 8.11.35.  
*Eucyclops serrulatus* (Fischer). Quelques jeunes.  
*Acanthocyclops bicuspidatus* Claus. Plusieurs, surtout jeunes.
- MÉCHHED.** 930 m.  
Bassin d'un autre jardin. 8.11.35.  
*Thermocyclops hyalinus* (Rehberg). Plusieurs ♀♀.
- PASGHALÉH (CHEMIRAN).** Environ 1375 m.  
Dans de la mousse auprès d'une cascade. 13.10.39.  
*Eucyclops serrulatus* (Fischer)? 1 ♀ jeune.
- PASGHALÉH (CHEMIRAN).** Environ 1375 m.  
Mare d'un torrent. 13.10.39.  
*Eucyclops rutneri elburziensis* Lindberg. 1 ♀.  
*Paracyclops fimbriatus* (Fischer). 1 ♂, 1 ♀.  
*Thermocyclops* sp. 1 copépodite.
- PAZANOUN.** Environ 15 km. à l'ouest de Béhéhan.  
Torrent sans végétation à eau limpide. 31.1.40.  
*Metacyclops minutus* Claus. Une trentaine.
- QAZVINE.** 1274 m.  
Bassin d'une maison particulière. 12.11.39.  
*Megacyclops viridis* Jurine. Quelques.  
*Acanthocyclops bicuspidatus* Claus. 1 ♂.
- QAZVINE.** 1274 m.  
Bassin d'un caravansérail. 12.11.39.  
*Cyclops strenuus divergens* Lindberg. 5 jeunes.  
*Megacyclops viridis* Jurine. 2 jeunes.  
*Acanthocyclops bicuspidatus* Claus. Quelques.  
*Microcyclus bicolor* Sars. 1 ♀.
- QAZVINE.** 1274 m.  
Bassin d'une petite mosquée. 12.11.39.  
*Cyclops strenuus divergens* Lindberg. Plusieurs.  
*Acanthocyclops bicuspidatus* Claus. Plusieurs.
- QAZVINE.** 1274 m.  
Autre bassin de la mosquée du Roi. 12.11.39.  
*Cyclops strenuus divergens* Lindberg. Nombreux.
- QAZVINE.** 1274 m.  
Autre bassin d'une petite mosquée. 12.11.39.  
*Cyclops strenuus divergens* Lindberg. Assez nombreux jeunes.  
*Acanthocyclops bicuspidatus* Claus. Plusieurs.
- QAZVINE.** 1274 m.  
Bassin de la mosquée principale. 12.11.39.  
*Cyclops strenuus divergens* Lindberg. Très nombreux.
- QAZVINE.** 1274 m.  
Autre bassin de la mosquée principale. 12.11.39.  
*Cyclops strenuus divergens* Lindberg. Assez nombreux.
- QOUM.** 1061 m.  
Fleuve saline. 22.9.35.  
*Eucyclops serrulatus* (Fischer). Quelques.
- QOUM.** 1061 m.  
Citerne à l'eau saumâtre. 23.9.35.  
*Cyclops strenuus divergens* Lindberg. Assez nombreux.  
*Acanthocyclops bicuspidatus* Claus. Assez nombreux.
- QOUM.** 1061 m.  
Autre citerne à l'eau saumâtre. 23.9.35.  
*Cyclops strenuus divergens* Lindberg. Plusieurs.
- QOUM.** 1061 m.  
Autre citerne à l'eau saumâtre. 23.9.35.  
*Acanthocyclops bicuspidatus odessanus* Chmank 5 ♀♀ et plusieurs jeunes.
- RÉY.** 1015 m. près Téhéran.  
Bras-mort d'un canal d'irrigation. 16.11.39.  
*Cyclops strenuus divergens* Lindberg. Plusieurs.
- ROBAT-KHAN.** Environ 880 m. à 80 km. au sud-ouest de Golchan (Tebbès).  
Etang salin. 4.11.35.  
*Eucyclops serrulatus* (Fischer). Quelques.  
*Megacyclops viridis* Jurine. 4 ou 5 ♀♀.
- SAGHAND.** 1240 m. à environ 100 km. au nord-est de Yazd.  
Bassin de la mosquée. 3.11.35.  
*Thermocyclops tinctus* Lindberg. Nombreux, surtout jeunes.
- SEBZÉVAR.** 1038 m.  
Bassin du Jardin national. 10.11.35.  
*Metacyclops minutus* Claus. Assez nombreux.

B. PLATEAU, MONTAGNES DU SUD, NORD-EST—*conclld.*

TANG-GAZ. Défilé à environ 6 km. au sud d'Amkhédabad (Dingar).

Mares de rivière à l'eau saumâtre. 5.3.40.  
*Eucyclops serrulatus* (Fischer). 4 ♂♂,  
6 ♀♀, 2 copépodites.

*Metacyclops minutus* Claus. Quelques.  
*Metacyclops grandispinifer* Lindberg. 1 ♀.  
*Metacyclops planus* Gurney. 1 ♀.  
*Mesocyclops leuckarti* Claus. 1 ♀.  
*Thermocyclops tinctus* Lindberg. 3 ♀♀.

TANG-PAZANOUN. Défilé entre Dihak et Kourdéh.

Mare de rivière d'eau douce. 4.3.40.  
*Microcyclops varicans* Sars. Quelques.

TANG-QIL. Environ 24 km. au nord-ouest de Galléhdar.

Réservoir à ciel ouvert. 2.3.40.  
*Metacyclops minutus* Claus. 44 ♂, 88 ♀♀,  
36 copépodites.  
*Thermocyclops vermifer* Lindberg. 10 ♀♀,  
1 copépodite.

TANG-QIL. Environ 24 km. au nord-est de Galléhdar.

Mares de rivière d'eau douce à environ 2 km. du réservoir.  
*Eucyclops serrulatus* (Fischer). 4 ♂♂,  
5 ♀♀, 2 copépodites.  
*Tropocyclops confinis* Kiefer. Plusieurs.  
*Microcyclops varicans* Sars. 2 ♀♀.  
*Metacyclops minutus* Claus. Nombreux  
♂♂, 2 ♀♀, 2 copépodites.  
*Thermocyclops tinctus* Lindberg. 38 ♂♂,  
13 ♀♀, 15 copépodites.

TEHAMELKÉH. Nord-ouest de Kourdéh, à environ 13 km. de Dizgah.

Roud Ambar Sefid, rivière à l'eau saumâtre, tribulaire du Mand. 4.3.40.  
*Eucyclops agioides* Sars. Nombreux.

TÉNÉRIAN. 1132 m.

Bassin de la gare du chemin de fer de Chah Abdol Azim. 16.11.39.  
*Cyclops strenuus divergens* Lindberg.  
1 ♀.

## C. PROVINCES CASPIENNES.

ASTANKÉH. Entre Recht et Lahidjan.

Bassin de la mosquée. 2.11.39.  
*Acanthocyclops bicuspidatus* Claus. Quelques.

BABOL.

Puits à l'eau saumâtre. 20.11.39.  
*Acanthocyclops bicuspidatus* Claus. Peu,  
surtout ♂♂.

BABOL.

Ruisseau. 20.11.39.  
*Megacyclops viridis* Jurine. 1 ♀ jeune.

BÉCHAHIR (ACHREF).

Bassin. 24.11.39.  
*Eucyclops serrulatus* (Fischer). 1 ♀  
jeune.  
*Megacyclops viridis* Jurine. 2 ♀♀  
jeunes.  
*Thermocyclops vermifer* Lindberg. 1 ♂,  
5 ♀♀.

BENDER CHAH.

Mare au bord de la mer. 26.11.39.  
*Acanthocyclops bicuspidatus* Claus.  
Nombreux, surtout jeunes.

BENDER CHAH.

Mare au bord de la mer. 26.11.39.  
*Megacyclops viridis* Jurine. 1 ♂, 2 ♀♀.  
*Acanthocyclops bicuspidatus* Claus.  
Jeunes.

BENDER CHAH.

Mare au bord de la mer. 26.11.39.  
*Acanthocyclops bicuspidatus* Claus.  
Jeunes.

BENDER CHAH.

Mare au bord de la mer. 26.11.39.  
*Acanthocyclops bicuspidatus* Claus. Nom-  
breux, surtout jeunes.

BENDER GAZ.

Rivière. 25.11.39.  
*Acanthocyclops vernalis* Fischer. Quel-  
ques ♂♂ et ♀♀.  
*Metacyclops planus* Gurney. 1 ♀.

BENDER GAZ.

Bassin de l'usine de savon, eau à température d'environ 40°C. 25.11.39.  
*Mesocyclops leuckarti* Claus. Très nom-  
breux.

BENDER GAZ.

Mare près de la voie ferrée. 25.11.39.  
*Cyclops caspicus*. 1 ♂, 1 ♀.  
*Acanthocyclops vernalis* Fischer. 1 ♂.  
*Acanthocyclops bicuspidatus* Claus. Quel-  
ques.

BENDER GAZ.

Marécage entre la ville et la mer. 25.11.39.  
*Cyclops caspicus* Lindberg. 1 ♂, 6 ♀♀,  
2 copépodites.  
*Megacyclops viridis* Jurine. 4 ♀♀, quel-  
ques copépodites.  
*Acanthocyclops bicuspidatus odessanus*  
Chmank. Nombreux.  
*Metacyclops planus* Gurney. 1 ♀.

BENDER GAZ.

Marais près de la mer. 25.11.39.  
*Cyclops caspicus* Lindberg. 2 ♂♂, quel-  
ques ♀♀.  
*Acanthocyclops bicuspidatus odessanus*  
Chmank. Quelques.  
*Mesocyclops leuckarti* Claus. 1 ♂, quel-  
ques copépodites.

CHAH. (ALIABAD).

Petite mare. 19.11.39.  
*Metacyclops planus* Gurney. 2 ♀♀.  
*Mesocyclops leuckarti* Claus. 3 ♀♀,  
2 copépodites.

C. PROVINCES CASPIENNES--*contd.*

## CHAH (ALIBAD).

Mare du fleuve Talar. 20.11.39.

*Macrocylops albidus* Jurine. 2 ♀♀.*Eucyclops serrulatus* (Fischer). Quelques.*Paracyclops vagus* Lindberg. 1 ♂, 3 ♀♀.*Ectocyclops rubescens* Brady. 1 ♀.*Megacyclops viridis* Jurine. Quelques jeunes.

## CHAH (ALIBAD).

Fosse. 19.11.39.

*Macrocylops fuscus* Jurine. 1 ♀, quelques jeunes.*Eucyclops serrulatus* (Fischer). Quelques.

## CHAH (ALIBAD).

Rizièr. 19.11.39.

*Macrocylops albidus* Jurine. 1 ♀ ovigère, une dizaine de jeunes.*Eucyclops serrulatus* (Fischer). 1 jeune.*Ectocyclops rubescens* Brady. 2 ♂♂, 1 ♀, quelques jeunes.*Cyclops strenuus divergens* Lindberg. 2 ♂♂, 9 ♀♀ jeunes.*Megacyclops viridis* Jurine. 1 ♀, quelques jeunes.*Microcylops varicans* Sars. 1 ♂, 1 ♀.*Mesocyclops leuckarti* Claus. 4 ♀♀, jeunes.

## CHAH (ALIBAD).

Etang eutrophique. 19.11.39.

*Macrocylops fuscus* Jurine. 2 ♀♀.*Macrocylops albidus* Jurine. 1 ♀, 3 jeunes.*Eucyclops macruoides* (Lilljeborg). 2 ♂♂, 2 ♀♀.*Ectocyclops rubescens* Brady. 1 ♂.*Megacyclops viridis* Jurine. 1 ♀ et quelques jeunes.*Melacyclops planus* Gurney. 1 ♀.*Mesocyclops leuckarti* Claus. 3 copépodites.*Thermocyclops vermifer* Lindberg. 1 ♀.

## CHAH (ALIBAD).

Fosse. 19.11.39.

*Eucyclops serrulatus* (Fischer). 1 ♀.*Megacyclops viridis* Jurine. 1 ♀.*Acanthocyclops bicuspidatus* Claus. Quelques.*Acanthocyclops bisetosus* Rehberg. Quelques.

## CHAH (ALIBAD).

Mare du fleuve Talar. 20.11.39.

*Macrocylops albidus* Jurine. 1 ♀, 1 copépodite.*Megacyclops viridis* Jurine. 2 jeunes.*Acanthocyclops bicuspidatus* Claus. Quelques.

## CHAH (ALIBAD).

Fosse près du fleuve Talar. 20.11.39.

*Macrocylops albidus* Jurine. 1 ♀, 2 jeunes.*Eucyclops serrulatus* (Fischer). 1 ♀.*Paracyclops vagus* Lindberg. 4 ♀♀.*Ectocyclops rubescens* Brady. 7 ♀♀.*Megacyclops viridis* Jurine. Quelques jeunes.*Microcylops varicans* Sars. 1 ♀, 1 jeune.

## CHAH (ALIBAD).

Mare eutrophique près d'un ruisseau.

20.11.39.

*Macrocylops fuscus* Jurine. 1 ♂, 1 ♀.*Eucyclops serrulatus* (Fischer). 4 ♂♂,

9 ♀♀, 2 copépodites.

*Paracyclops vagus* Lindberg. 3 ♀♀.*Ectocyclops rubescens* Brady. 3 ♀♀, 3 copépodites.*Megacyclops viridis* Jurine. 2 ♀♀, nombreux jeunes.*Acanthocyclops bisetosus* Rehberg. 2 ♀♀, 2 jeunes.*Microcylops varicans* Sars. 5 ♀♀.

## GORGAN (ASTÉRABAD). 110 m.

Mare sans végétation. 27.11.39.

*Eucyclops serrulatus* (Fischer). 5 ♂♂,

13 ♀♀, 9 copépodites.

*Acanthocyclops bisetosus* Rehberg. Quelques jeunes.*Microcylops varicans* Sars. 1 ♂, 8 ♀♀, 30 copépodites.*Melacyclops planus* Gurney. 4 ♀♀, 2 copépodites.*Thermocyclops rylori* Smirnov. 1 ♀, 1 jeune.

## GORGAN (ASTÉRABAD). 110 m.

Trou d'eau. 27.11.39.

*Acanthocyclops bicuspidatus* Claus. Quelques jeunes.*Melacyclops minutus* Claus. 1 ♀.

## GORGAN (ASTÉRABAD). 110 m.

Bassin. 27.11.39.

*Melacyclops planus* Gurney. 1 ♀, 4 copépodites.

## GORGAN (ASTÉRABAD). 110 m.

Autre bassin. 27.11.39.

*Eucyclops serrulatus* (Fischer). 1 ♂, 1 ♀.*Megacyclops viridis* Jurine. 6 jeunes.*Acanthocyclops bicuspidatus* Claus. 1 jeune.*Microcylops varicans* Sars. 1 ♀.*Mesocyclops leuckarti* Claus. 5 copépodites.

## GORGAN (ASTÉRABAD). 110 m.

Fosse. 27.11.39.

*Acanthocyclops bisetosus* Rehberg. 1 ♂, plus de 40 jeunes.

## GORGAN (ASTÉRABAD). 110 m.

Petite mare. 27.11.39.

*Acanthocyclops bisetosus* Rehberg. 1 ♂, quelques jeunes.

## GORGAN (ASTÉRABAD). 110 m.

Mare temporaire sans végétation au bord d'une route. 27.11.39.

*Eucyclops serrulatus* (Fischer). Quelques.

## GORGAN (ASTÉRABAD). 110 m.

Mare d'une four à briques. 27.11.39.

*Acanthocyclops bicuspidatus* Claus. Plusieurs ♂♂ et jeunes.*Thermocyclops* sp. 2 copépodites.

## GORGAN (ASTÉRABAD). 110 m.

Mare. 27.11.39.

*Eucyclops serrulatus* (Fischer). Quelques.

C. PROVINCES CASPIENNES—*contd.*

- KALATCHAYÉH.** Sur la côte de la mer Caspienne, à environ 13 km. à l'est de Langueroud.  
Petit étang près du bord de la mer. 7.11.39.  
*Acanthocyclops bisetosus* Rehberg. Peu.
- KALATCHAYÉH.** Sur la côte de la mer Caspienne, à environ 13 km. à l'est de Langueroud.  
*Acanthocyclops bicuspidatus* Claus. Plusieurs.
- LAHIDJAN.**  
Rizière. 30.10.39.  
*Eucyclops serrulatus* (Fischer). Plusieurs.  
*Megacyclops viridis* Jurine. Assez nombreux.  
*Acanthocyclops bicuspidatus* Claus. Plusieurs.  
*Acanthocyclops bisetosus* Rehberg. 1 ♂, 1 ♀.  
*Microcyclops varicans* Sars. 1 ♀.
- LAHIDJAN.**  
Étang de l'Institut agricole. 31.10.39.  
*Megacyclops viridis* Jurine. 3 ♂♂, 8 ♀♀, 5 copépodites.  
*Acanthocyclops bicuspidatus* Claus. 1 ♀, 1 copépodite.  
*Microcyclops varicans* Sars. 5 ♂♂, 4 ♀♀, 7 copépodites.  
*Microcyclops linjanticus* Kiefer. 1 ♂, 1 ♀.  
*Mesocyclops leuckarti* Claus. 3 ♀♀.
- LAHIDJAN.**  
Petite rivière. 30.10.39.  
*Megacyclops viridis* Jurine. Quelques.  
*Acanthocyclops bicuspidatus* Claus. 3 ♀♀, quelques jeunes.
- LAHIDJAN.**  
Fosse. 31.10.39.  
*Acanthocyclops bicuspidatus* Claus. Peu.
- LAHIDJAN.**  
Puits. 31.10.39.  
*Acanthocyclops vernalis* Fischer. Quelques.  
*Acanthocyclops bicuspidatus* Claus. Quelques jeunes.
- LAHIDJAN.**  
Fosse. 30.10.39.  
*Megacyclops viridis* Jurine. 2 ♂♂, 6 ♀♀.  
*Acanthocyclops bicuspidatus* Claus. 4 ♀♀.
- LAHIDJAN.**  
Mare. 31.10.39.  
*Megacyclops viridis* Jurine. 1 ♂, 1 ♀.  
*Acanthocyclops bisetosus* Rehberg. Peu.
- LAHIDJAN.**  
Marais. 31.10.39.  
*Eucyclops serrulatus* (Fischer). 3 ♂♂.  
*Cyclops strenuus divergens* Lindberg. 1 ♀.  
*Acanthocyclops bicuspidatus* Claus. 4 ♂♂, 1 ♀.  
*Mesocyclops leuckarti* Claus. 2 ♂♂, 1 ♀.
- LAHIDJAN.**  
Fosse. 31.10.39.  
*Megacyclops viridis* Jurine. 39 ♀♀ (dont 14 ovigères).  
*Acanthocyclops vernalis* Fischer. 1 ♀.  
*Acanthocyclops bicuspidatus* Claus. 1 ♂, 2 ♀♀.  
*Microcyclops richardi* Lindberg. 2 ♀♀.
- LAHIDJAN.**  
Fosse profonde, à végétation. 31.10.39.  
*Megacyclops viridis* Jurine. Quelques ♀♀ et jeunes.  
*Acanthocyclops bicuspidatus* Claus. Plusieurs, surtout jeunes.
- LAHIDJAN.**  
Fosse. 30.10.39.  
*Eucyclops serrulatus* (Fischer). 1 ♀.  
*Megacyclops viridis* Jurine. Nombreux.  
*Cyclops kozminskii* Lindberg. 1 ♀.  
*Acanthocyclops bicuspidatus* Claus. Quelques.
- LANGUEROU.**  
Puits. 2.11.39.  
*Acanthocyclops bicuspidatus* Claus. 1 ♀.
- LANGUEROU.**  
Mare.—2.11.39.  
*Eucyclops serrulatus* (Fischer). 1 ♀.  
*Megacyclops viridis* Jurine. Quelques.  
*Acanthocyclops bicuspidatus* Claus. Quelques.  
*Mesocyclops leuckarti* Claus. 2 ♀♀.
- PAHLÉVI (ENZÉLI).**—26 m.  
Rivière. 10.11.39.  
*Eucyclops serrulatus* (Fischer). 4 ♀♀.
- PAHLÉVI (ENZÉLI).**—26 m.  
Mourad ab (Lagune). 10.11.39.  
*Eucyclops serrulatus* (Fischer). Quelques.  
*Megacyclops viridis* Jurine. 1 ♀.  
*Acanthocyclops bisetosus* Rehberg. 32 jeunes.
- PAHLÉVI (ENZÉLI).**—26 m.  
Mares d'eau de pluie. 9.11.39.  
*Acanthocyclops bisetosus* Rehberg. Assez nombreux.
- PAHLÉVI (ENZÉLI).**—26 m.  
Puits. 9.11.39.  
*Acanthocyclops bicuspidatus* Claus. Nombreux.
- PAHLÉVI (ENZÉLI).**—26 m.  
Mourad ab (Lagune). 10.11.39.  
*Eucyclops serrulatus* (Fischer). Quelques.  
*Cyclops strenuus divergens* Lindberg. 1 ♂.  
*Acanthocyclops bisetosus* Rehberg. Quelques.
- PAHLÉVI (ENZÉLI).**—26 m.  
Mare remplie de bois pourri. 9.11.39.  
*Megacyclops viridis* Jurine. 1 ♀ jeune.  
*Acanthocyclops bisetosus* Rehberg. Plusieurs.
- PAHLÉVI-GHAZIAN.**—26 m.  
Mare. 10.11.39.  
*Megacyclops viridis* Jurine. Plusieurs.  
*Acanthocyclops robustus* Sars. 1 ♀.

C. PROVINCES CASPIENNES—*contd.*

## PAHLÉVI-GHAZIAN.—26 m.

Puits 10.13.39.

*Megacyclops viridis* Jurine. 4 ♀♀ jeunes.*Acanthocyclops vernalis* Fischer. 2 ♀♀.*Acanthocyclops bicuspidatus* Claus. 3 ♂♂,  
5 ♀♀, 1 copépodite.

## PAHLÉVI-GHAZIAN.—26 m.

Étang. 10.11.39.

*Megacyclops viridis* Jurine. Plusieurs.*Microcyclops linjanticus* Kiefer. Assez nombreux.*Thermocyclops dybowskii* Lande. 2 ♀♀.

## PAHLÉVI-GHAZIAN.—26 m.

Mare. 10.11.39.

*Megacyclops viridis* Jurine. 1 ♀.*Acanthocyclops robustus* Sars. 1 ♀.*Acanthocyclops bicuspidatus* Claus. 2 ♀♀.*Acanthocyclops bisetosus* Rehberg. Quelques.

## PAHLÉVI-GHAZIAN.—26 m.

Mare d'eau de pluie. 9.11.39.

*Megacyclops viridis* Jurine. Quelques jeunes.*Acanthocyclops robustus* Sars. 2 ♂♂, 1 ♀.

## RAMSAR.—26 m.

Mare près d'un torrent. 29.10.39.

*Macrocyclus albidus* Jurine. 1 ♀.*Eucyclops serrulatus* (Fischer). 93 ♂♂,  
68 ♀♀, 21 copépodites.*Paracyclops vagus* Lindberg. 3 ♀♀.*Megacyclops viridis* Jurine. 1 ♀, 2 jeunes.*Acanthocyclops bisetosus* Rehberg. 30

jeunes.

*Mesocyclops leuckarti* Claus. 1 ♀.

## RAMSAR.—26 m.

Mare. 4.11.39.

*Megacyclops viridis* Jurine. 2 ♀♀.*Acanthocyclops robustus* Sars. 1 ♀, 4

jeunes.

*Acanthocyclops bisetosus* Rehberg. 2 ♀♀.

## RAMSAR.—26 m.

Petit étang. 4.11.39.

*Eucyclops serrulatus* (Fischer). 1 ♂.*Ectocyclops rubescens* Brady. 2 ♀♀.*Megacyclops viridis* Jurine. Quelques.*Acanthocyclops bicuspidatus* Claus. Quelques.*Microcyclops varicans* Sars. 2 ♀♀.*Mesocyclops leuckarti* Claus. 1 ♀.

## RAMSAR.—26 m.

Marécage. 4.11.39.

*Megacyclops viridis* Jurine. Plusieurs.*Acanthocyclops robustus* Sars. Quelques.*Acanthocyclops bisetosus* Rehberg. Quelques.

## RAMSAR.—26 m.

Marais. 29.10.39.

*Eucyclops serrulatus* (Fischer) Plusieurs.*A. anthocyclops bisetosus* Rehberg. Plusieurs.

ours.

## RAMSAR.—26 m.

Mare. 29.10.39.

*Macrocyclus albidus* Jurine. 1 ♀.*Eucyclops serrulatus* (Fischer). Peu.

## RAMSAR.—26 m.

Trou d'eau. 4.11.39.

*Megacyclops viridis* Jurine. Plusieurs.*Acanthocyclops bisetosus* Rehberg. Nom-

breux.

## RECHT.—15 m.

Mare. 3.11.39.

*Macrocyclus albidus* Jurine. Quelques

jeunes.

*Eucyclops serrulatus* (Fischer). 4 ♂♂,  
6 ♀♀.*Paracyclops vagus* Lindberg. 1 ♂.*Megacyclops viridis* Jurine. 1 ♂, 7 ♀♀,

nombreux copépodites.

*Acanthocyclops bicuspidatus* Claus. 5 ♂♂,  
5 ♀♀, très nombreuses copépodites.*Acanthocyclops bisetosus* Rehberg. Quel-

ques ♀♀ jeunes et copépodites.

*Microcyclops varicans* Sars. 7 ♂♂, 9 ♀♀.*Microcyclops linjanticus* Kiefer. 2 ♀♀.*Mesocyclops leuckarti* Claus. 3 ♂♂,  
5 ♀♀, assez nombreuses copépodites.*Thermocyclops dybowskii* Lande. 5 ♀♀,  
1 copépodite.

## RECHT.—15 m.

Ruissseau. 1.11.39.

*Eucyclops serrulatus* (Fischer). 1 ♀

jeune, 5 copépodites.

*Megacyclops viridis* Jurine. 1 ♀, 1 copé-

podite.

*Acanthocyclops robustus* Sars. 1 ♀.*Acanthocyclops bisetosus* Rehberg. 2 ♀♀.*Microcyclops varicans* Sars. 1 ♀.*Mesocyclops leuckarti* Claus. 4 ♂♂, 1 ♀.*Thermocyclops tylovi* Smirnov. 1 ♂.

## RECHT.—15 m.

Bassin. 8.11.39.

*Acanthocyclops bicuspidatus* Claus. Assez

nombreux.

## RECHT.—15 m.

Rivière. 3.11.39.

*Megacyclops viridis* Jurine. 1 jeune.*Acanthocyclops bicuspidatus* Claus 1 ♂,  
1 ♀.

## RECHT.—15 m.

Fosse. 1.11.39.

*Megacyclops viridis* Jurine. Plusieurs.*Acanthocyclops vernalis* Fischer. Plusi-

curs.

*Acanthocyclops bicuspidatus* Claus. Quel-

ques.

## RECHT.—15 m.

Mare. 3.11.39.

*Megacyclops viridis* Jurine. 2 ♀♀, très

nombreux copépodites.

*Acanthocyclops bicuspidatus* Claus. Nom-

breux, surtout jeunes.

*Microcyclops linjanticus* Kiefer. 1 ♀.

C. PROVINCES CASPIENNES—*contd.*

## RECHT.—15 m.

Fosse. 3.11.39.

*Megacyclops viridis* Jurine. Plusieurs.*Acanthocyclops vernalis* Fischer. Quelques.*Acanthocyclops bicuspidatus* Claus. Quelques.

## RECHT.—15 m.

Puits. 8.11.39.

*Acanthocyclops bicuspidatus* Claus. Nombreux.

## RECHT.—15 m.

Fosse. 3.11.39.

*Megacyclops viridis* Jurine. Quelques.*Acanthocyclops vernalis* Fischer. Quelques.

## SARI.

Mare dans les champs. 22.11.39.

*Acanthocyclops vernalis* Fischer. 1 ♀.

## SARI.

Mare. 23.11.39.

*Eucyclops serrulatus* (Fischer). 1 ♂, 1 ♀, 3 copépodites.*Acanthocyclops bicuspidatus* Claus. Peu.

## SARI.

Bassin. 23.11.39.

*Eucyclops serrulatus* (Fischer). 3 ♀♀.)*Microcyclops linjanticus* Kiefer. 1 ♀.*Metacyclops* sp. 1 copépodite.*Mesocyclops leuckarti* Claus. 10 ♂♂, 2 copépodites.*Thermocyclops vermifer* Lindberg. 15 ♂♂, 76 ♀♀, 29 copépodites.

## SARI.

Fosse d'excavation près de la voie ferrée. 22.11.39.

*Eucyclops serrulatus* (Fischer). 1 ♂.*Paracyclops vagus* Lindberg. 1 ♂.*Ectocyclops rubescens* Brady. 2 ♀♀.*Microcyclops varicans* Sars. 1 ♀, 7 copépodites.*Mesocyclops leuckarti* Claus. 1 ♀.

## SARI.

Rizière. 22.11.39.

*Eucyclops serrulatus* (Fischer). Quelques.*Paracyclops vagus* Lindberg. 1 ♀.*Ectocyclops rubescens* Brady. 1 ♀.*Microcyclops varicans* Sars. 1 ♀.*Mesocyclops leuckarti* Claus. 1 ♀.

*Cyclops (Metacyclops) planus* Gurney.

Localité.	Longueur μ.	Furca Long. : larg.	Soie dors.	Soies apicales.	Enp. 4. Art. 2. Long. : larg.	Enp. 4. Art. 2. Long. art. : ép. apic.	P 6 Epine : soie.
<i>Abadan</i>	♂ 675	(48+42) : 22=4.09 : 1	43	65 : 179 : X : 43	52 : 17=3.06 : 1	53 : 52=1 : 1	37 : 26
<i>Chouch (Suse)</i>	♀ 789	(45+35) : 22=3.63 : 1	42	55 : 147 : 295 : 35	48 : 25=1.92 : 1	48 : 48=1 : 1	
<i>Dizfoul</i>	♀ 931	(58+40) : 22=4.45 : 1	47	53 : 138 X : 33	52 : 26=2 : 1	52 : 48=1.08 : 1	
<i>Khorramchahr</i>	♀ 803	(55+45) : 20=5 : 1	50	57 : 157 : 290 : 37	48 : 27=1.78 : 1	48 : 43=1.12 : 1	
	♂ 708	(48+42) : 20=4.50 : 1	47	63 : 179 : 334 : 53	53 : 16=3.31 : 1	53 : 47=1.13 : 1	42 : 37
<i>Mansouriyéh</i>	♀ 827	(41+42) : 23=3.60 : 1	53	52 : 138 : 292 : 38	50 : 25=2 : 1	50 : 41=1.22 : 1	
<i>Tang-Gaz</i>	♀ 798	(46+42) : 20=4.40 : 1	45	59 : 163 : 319 : 37	50 : 28=1.78 : 1	50 : 53=0.94 : 1	
<i>Bender Gaz</i>	♀ 760	(42+40) : 22=3.73 : 1	45	52 : 127 : 325 : 33	50 : 25=2 : 1	50 : 55=0.90 : 1	
<i>Chahi</i>	♀ 765	(47+43) : 25=3.60 : 1	50	67 : 160 : 300 : 30	53 : 30=1.77 : 1	53 : 45=1.18 : 1	
<i>Gorgan</i>	♀ 893	(41+37) : 22=3.54 : 1	47	50 : 138 : 309 : 35	52 : 26=2 : 1	52 : 49=1.06 : 1	

*Cyclops (Aporocyclops) dengizicus* Lepechkin ♂.

Localité.	Longueur μ.	Furca Long. : larg.	Soie dors.	Soies apicales.	Enp. 4. Art. 2. Long. : larg.	Enp. 4. Art. 2. Soie ap. int. : ép. ap. ext.	Enp. 4. Art. 2. Long. art. : ép. ap.	P 6 Ep. : soie med. : soie ext.
<i>Abd Imam</i>	276	(80+50) : 27=4.81 : 1	63	48 : 275 : 317 : 50	53 : 32=1.81 : 1	100 : 78=1.28 : 1	53 : 78=0.88 : 1	38 : 27 : 33
<i>Guenavéh</i>	247	(87+83) : 22=7.73 : 1	78	58 : 279 : 342 : 80	58 : 28=2.07 : 1	..	58 : 85=0.68 : 1	53 : 23 : 38
		(85+65) : 20=7.50 : 1	70	57 : 277 : 332 : 67	58 : 35=1.66 : 1	90 : 87=1.03 : 1	58 : 87=0.67 : 1	

*Mesocyclops leuckarti* Claus ♀.

	NORD.			SUD.		
	Nombre.	Moyenne.	Valeurs extrêmes.	Nombre.	Moyenne.	Valeurs extrêmes.
Longueur $\mu$	7	1196	1074—1359	38	1407	893—1663
Furca. Longueur : largeur	7	3 : 1	2.68 : 1—3.24 : 1	36	3.52 : 1	2.86 : 1—4.24 : 1
Furca. Soie dorsale $\mu$	7	82	67—100	36	103	75—138
Enp. 4. Art. 3. Longueur : largeur	6	2.59 : 1	2.32 : 1—2.96 : 1	36	2.71 : 1	2.34 : 1—3.33 : 1
Enp. 4. Art. 3. Ep. apic. int. : ép. apic. ext.	7	1.01 : 1	0.9 : 1—1.15 : 1	36	1.16 : 1	0.88 : 1—1.41 : 1
Enp. 4. Art. 3. Long. art. : ép. apic. int.	6	1.09 : 1	0.96 : 1—1.18 : 1	36	1.16 : 1	1.05 : 1—1.43 : 1

*Mesocyclops leuckarti* Claus ♂.

Longueur $\mu$	4	835	779—893	33	956	756—1117
Furca. Longueur : largeur	4	2.79 : 1	2.62 : 1—3.04 : 1	32	3.19 : 1	2.68 : 1—3.72 : 1
Furca. Soie dorsale $\mu$	3	59	53—67	27	82	67—97
Enp. 4. Art. 3. Longueur : largeur	4	2.94 : 1	2.64 : 1—3.22 : 1	26	3.11 : 1	2.65 : 1—3.65 : 1
Enp. 4. Art. 3. Ep. apic. int. : ép. apic. ext.	4	0.92 : 1	0.86 : 1—1 : 1	26	1.16 : 1	0.75 : 1—1.62 : 1
Enp. 4. Art. 3. Long. art. : ép. apic. int.	4	1.11 : 1	1.03 —1.23 : 1	26	1.18 : 1	1 : 1—1.62 : 1
P 6. Epine : soie méd. : soie ext.	4	28 : 33 : 57	(27.30) : (28.37) : (55.60)	33	32 : 34 : 67	(25.50) : (22.53) : (50.92)



*Mesocyclops leuckarti* Claus ♀.

Localité.	Longueur µ.	Furca Long. : larg. ,	Furca Soie dors.	Enp. 4. Art. 3. Long. : larg.	Enp. 4. Art. 3. Ep. ap. int. : ép. ap. ext.	Enp. 4. Art. 3. Long. art. : ép. ap. int.
<i>Ahras</i> Bassin	1568	140 : 33=4.24 : 1 glabre	75	92 : 28=3.29 : 1	73 : 63=1.16 : 1	1.26 : 1
	1387	125 : 35=3.57 : 1 "	100	92 : 32=2.87 : 1	75 : 55=1.36 : 1	1.23 : 1
	1378	....	..	....	....	..
<i>Autre bassin</i>	1216	102 : 28=3.64 : 1 glabre	83	75 : 30=2.50 : 1	60 : 67=0.89 : 1	1.25 : 1
<i>Mare</i>	1387	108 : 31=3.48 : 1 "	77	75 : 30=2.50 : 1	58 : 62=0.94 : 1	1.29 : 1
<i>Autre bassin</i>	1254	105 : 30=3.50 : 1 "	83	80 : 27=2.96 : 1	60 : 60=1 : 1	1.33 : 1
<i>Akhtar</i> Puits	1254	123 : 33=3.73 : 1 "	95	82 : 30=2.73 : 1	73 : 60=1.22 : 1	1.12 : 1
<i>Ali (Oul'i)</i> Puits	1444	132 : 38=3.47 : 1 poils	112	92 : 37=2.49 : 1	87 : 79=1.10 : 1	1.06 : 1
<i>Aseclou</i> Puits	1596	117 : 37=3.16 : 1 glabre	103	90 : 37=2.45 : 1	80 : 63=1.27 : 1	1.12 : 1
<i>Bébbéhan</i> Réservoir à ciel ouvert	1359	120 : 33=3.64 : 1 poils	92	85 : 30=2.83 : 1	72 : 58=1.24 : 1	1.18 : 1
<i>Réservoir souterrain</i>	1549	130 : 35=3.71 : 1 "	83	90 : 33=2.73 : 1	80 : 67=1.19 : 1	1.12 : 1
<i>Bassin</i>	1292	107 : 33=3.24 : 1 "	108	85 : 31=2.74 : 1	78 : 63=1.24 : 1	1.09 : 1
<i>Citerne</i>	1283	108 : 33=3.27 : 1 "	92	78 : 28=2.78 : 1	68 : 57=1.19 : 1	1.14 : 1
<i>Puits</i>	1520	133 : 37=3.59 : 1 "	117	100 : 30=3.33 : 1	77 : 63=1.22 : 1	1.29 : 1
<i>Bender Chakpour</i> Citerne	1112	90 : 27=3.33 : 1 glabre	77	73 : 27=2.70 : 1	60 : 68=0.88 : 1	1.22 : 1
<i>Birikou</i> Citerne	1511	142 : 37=3.84 : 1 poils	118	97 : 35=2.77 : 1	92 : 67=1.37 : 1	1.05 : 1

<i>Boulkheir</i> Puits	1463	127 : 33 = 3.85 : 1 "	117	97 : 35 = 2.77 : 1	84 : 66 = 1.27 : 1	1.15 : 1
<i>Chouch</i> Gare. Citerne	1283	102 : 28 = 3.64 : 1 "	93	76 : 28 = 2.71 : 1	72 : 82 = 0.88 : 1	1.05 : 1
<i>Dayyir</i> Puits	893	113 : 33 = 3.42 : 1 glabre	127	88 : 32 = 2.75 : 1	75 : 67 = 1.12 : 1	1.17 : 1
<i>Djam</i> Puits	1378	117 : 35 = 3.34 : 1 poils	138	92 : 35 = 2.63 : 1	78 : 70 = 1.11 : 1	1.18 : 1
<i>Chemin vers Makkou</i> Rivière	1406	113 : 33 = 3.42 : 1 "	133	85 : 27 = 3.15 : 1	75 : 67 = 1.12 : 1	1.13 : 1
<i>Pirouzabad</i> Bassin	1159	100 : 33 = 3.03 : 1 glabre	.88	90 : 32 = 2.81 : 1	78 : 86 = 0.90 : 1	1.15 : 1
1092	....	....	..	....	....	..
<i>Hadakou</i> Puits	1568	128 : 40 = 3.20 : 1 poils	117	95 : 36 = 2.64 : 1	90 : 75 = 1.20 : 1	1.06 : 1
<i>Karri</i> Puits	1525	125 : 33 = 3.08 : 1 glabre	108	85 : 32 = 2.66 : 1	80 : 63 = 1.27 : 1	1.06 : 1
<i>Kourdeh</i> Puits	1416	115 : 33 = 3.18 : 1 "	117	92 : 33 = 2.78 : 1	85 : 75 = 1.13 : 1	1.08 : 1
<i>Pouzéh</i> Puits	1511	120 : 34 = 3.53 : 1 poils	105	85 : 34 = 2.50 : 1	73 : 63 = 1.24 : 1	1.09 : 1
<i>Réehir</i> puits	1321	123 : 33 = 3.73 : 1 "	103	90 : 32 = 2.81 : 1	75 : 63 = 1.19 : 1	1.20 : 1
<i>Tahiri</i> Réservoir	1653	142 : 42 = 3.38 : 1 glabre	123	98 : 40 = 2.45 : 1	87 : 67 = 1.29 : 1	1.13 : 1
<i>Chemin vers Nahhl Taqi</i> Puits	1435	125 : 38 = 3.29 : 1 poils	100	83 : 35 = 2.37 : 1	72 : 58 = 1.24 : 1	1.15 : 1
1434	127 : 37 = 3.43 : 1 glabre	100	87 : 33 = 2.64 : 1	75 : 65 = 1.15 : 1	1.16 : 1	1.16 : 1
<i>Zivhak</i> Puits	1663	135 : 38 = 3.55 : 1 poils	122	102 : 35 = 2.91 : 1	93 : 78 = 1.19 : 1	1.09 : 1
1630	137 : 38 = 3.60 : 1 "	128	103 : 35 = 2.94 : 1	83 : 72 = 1.15 : 1	1.24 : 1	1.24 : 1
1397	137 : 42 = 3.26 : 1 "	100	89 : 38 = 2.34 : 1	84 : 68 = 1.25 : 1	1.06 : 1	1.06 : 1
1558	135 : 36 = 3.75 : 1 "	95	95 : 33 = 2.88 : 1	82 : 58 = 1.41 : 1	1.06 : 1	1.06 : 1
<i>Khorram-hahr</i> Ruissau	1596	125 : 37 = 3.38 : 1 "	95	93 : 33 = 2.82 : 1	70 : 62 = 1.18 : 1	1.33 : 1
<i>Lar</i> Bassin						
Puits						

*Mesocyclops leuckarti* Claus ♀—contd.

Localité.	Longueur μ.	Furca Long. : larg. "	Furca Soie dors.	Enp. 4. Art. 3. Long. : larg.	Enp. 4. Art. 3. Ep. ap. int. : ép. ap. ext.	Enp. 4. Art. 3. Long. art. : ép. ap. int.
Réservoir	1558	135 : 36=3.75 : 1 poils	92	92 : 35=2.63 : 1	77 : 58=1.33 : 1	1.19 : 1
Citerne	1435	133 : 37=3.59 : 1 "	108	97 : 33=2.93 : 1	68 : 57=1.19 : 1	1.43 : 1
Bender Gaz Bassin	1264	100 : 35=2.86 : 1 glabre	67	77 : 32=2.40 : 1	75 : 65=1.15 : 1	1.03 : 1
Chahi Petite mare	1092	83 : 31=2.68 : 1 "	75	80 : 27=2.96 : 1	72 : 80=0.90 : 1	1.11 : 1
	1235	100 : 35=2.86 : 1 "	100	87 : 33=2.64 : 1	80 : 78=1.03 : 1	1.09 : 1
Lahidjan Etang	1102	88 : 28=3.14 : 1 "	83	....	67 : 67=1 : 1	..
	1074	83 : 28=2.96 : 1 "	87	80 : 27=2.96 : 1	68 : 66=1.03 : 1	1.18 : 1
Recht Ruiseau	1245	107 : 33=3.24 : 1 "	75	77 : 32=2.40 : 1	67 : 67=1 : 1	1.15 : 1
Sari Bassin	1359	113 : 37=3.05 : 1 "	90	88 : 38=2.32 : 1	92 : 90=1.02 : 1	0.96 : 1

*Mesocyclops leuckarti* Claus ♂.

Localité.	Longueur μ.	Furca Long. : larg.	Furca Soie dors.	Enp. 4. Art. 3. Long. : larg.	Enp. 4. Art. 3. Ep. ap. int. : ép. ap. ext.	Enp. 4. Art. 3. Long. art. : ép. ap. int.	P 6 Epine : soie méd : soie ext.
Ahvaz Bassin	893	67 : 20=3.35 : 1	92	52 : 18=2.89 : 1	43 : 51=0.84 : 1	1.21 : 1	27 : 23.58
Autre bassin	779	67 : 18=3.72 : 1	82	60 : 18=3.33 : 1	50 : 53=0.94 : 1	1.20 : 1	23 : 33 : 63

Autre bassin	874	70 : 19=3-68 : 1	..	57 : 18=3-17 : 1	40 : 42=0-95 : 1	1-42 : 1	27 : 33 : 43
Akhar Puits	950	80 : 25=3-20 : 1	90	68 : 23=2-95 : 1	62 : 47=1-32 : 1	1-09 : 1	33 : 33 : 63
Ati (Ouli) Puits	1092	82 : 25=3-28 : 1	92	....	....	..	37 : 28 : 58
Assalou Puits	1064	87 : 26=3-35 : 1	83	....	....	..	..
	1092	83 : 27=3-07 : 1	83	70 : 22=3-18 : 1	67 : 47=1-43 : 1	1-04 : 1	27 : 33 : 70
Bébhéhan Bassin	993	82 : 25=3-28 : 1	..	70 : 22=3-18 : 1	58 : 47=1-23 : 1	1-20 : 1	30 : 43 : 75
Puits	893	70 : 23=3-04 : 1	88	58 : 20=2-90 : 1	58 : 46=1-26 : 1	1 : 1	33 : 33 : 83
Bender Chapour Citerne	794	63 : 19=3-32 : 1	..	57 : 18=3-17 : 1	43 : 53=0-81 : 1	1-33 : 1	27 : 33 : 58
	..	....	..	....	....	..	27 : 30 : 50
Mare	756	58 : 20=2-90 : 1	53	58 : 17=3-41 : 1	43 : 51=0-84 : 1	1-35 : 1	23 : 27 : 50
Birikou Réservoir	1017	90 : 25=3-60 : 1	92	....	....	..	45 : 53 : 75
Borazdjan Puits	827	67 : 22=3-04 : 1	83	60 : 20=3-0 : 1	53 : 37=1-43 : 1	1-13 : 1	28 : 38 : 53
Chouch Gare. Citerne	827	73 : 22=3-32 : 1	67	60 : 19=3-16 : 1	45 : 60=0-75 : 1	1-33 : 1	18 : 28 : 63
Dayyir Puits	1117	85 : 25=3-40 : 1	83	73 : 20=3-65 : 1	63 : 50=1-26 : 1	1-16 : 1	41 : 43 : 83
Djam Puits	941	75 : 22=3-41 : 1	97	....	....	..	33 : 30 : 83
Firouzaabad Bassin	903	67 : 25=2-68 : 1	67	65 : 21=3-09 : 1	43 : 54=0-79 : 1	1-51 : 1	30 : 42 : 67
Hadakou Puits	1017	75 : 27=2-78 : 1	85	....	....	..	34 : 37 : 75
Karri Puits	1017	80 : 27=2-96 : 1	67	77 : 23=3-35 : 1	75 : 56=1-34 : 1	1-03 : 1	38 : 50 : 70
Khorab Rivière	760	58 : 20=2-90 : 1	67	63 : 18=3-50 : 1	45 : 28=1-60 : 1	1-62 : 1	50 : 22 : 67
Kourdéh Puits	959	77 : 24=3-20 : 1	88	67 : 22=3-04 : 1	62 : 50=1-24 : 1	1-08 : 1	30 : 37 : 78

*Mesocyclops leuckartii* Claus ♂—contd.

Localité.	Longueur μ.	Furca Long. : larg.	Furca Soie dors.	Enp. 4. Art. 3. Long. : larg.	Enp. 4. Art. 3. Ep. ap. int. : ép. ap. ext.	Enp. 4. Art. 3. Long. ap. int. : ép. ap. int.	P 6 Epine : soie méd. : soie ext.
<i>Pouzâ Puits</i>	979	82 : 25=3-28 : 1 .	83	67 : 23=2-91 : 1	63 : 42=1-50 : 1	1-06 : 1	33 : 27 : X
<i>Tahiri</i>	1102	83 : 26=3-19 : 1	..	....	....	..	35 : 27 : 67
	1045	78 : 25=3-12 : 1	..	....	....	..	33 : 30 : X
<i>Chemin vers Nakhl Taqi Puits</i>	950	83 : 26=3-19 : 1	88	67 : 20=3-35 : 1	63 : 45=1-62 : 1	1-06 : 1	37 : 37 : 67
	1017	83 : 26=3-19 : 1	92	....	....	..	37 : 33 : 67
<i>Zirhak Puits</i>	1074	83 : 27=3-07 : 1	92	....	....	..	37 : 40 : 83
	1045	....	..	....	....	..	33 : 43 : 92
<i>Lar Puits</i>	941	85 : 27=3-15 : 1	75	67 : 24=2-79 : 1	55 : 42=1-31 : 1	1-22 : 1	27 : 33 : 63
<i>Réservoir</i>	1007	90 : 28=3-21 : 1	92	72 : 23=3-13 : 1	60 : 47=1-28 : 1	1-20 : 1	31 : 37 : 58
<i>Citerne</i>	1102	90 : 25=3-60 : 1	78	63 : 23=2-83 : 1	52 : 42=1-24 : 1	1-25 : 1	31 : 37 : 67
<i>Khorranchahr Ruisseau</i>	903	75 : 24=3-12 : 1	83	53 : 20=2-65 : 1	52 : 38=1-37 : 1	1-02 : 1	28 : 33 : 58
	836	65 : 22=2-95 : 1	83	....	....	..	25 : 33 : 58
<i>Bender Gaz Bassin</i>	893	67 : 22=3-04 : 1	53	58 : 18=3-22 : 1	47 : 47=1-0	1-23 : 1	30 : 37 : 60
<i>Lahidjan Etang</i>	808	63 : 22=2-86 : 1	..	58 : 22=2-64 : 1	52 : 60=0-87 : 1	1-12 : 1	27 : 33 : 55
<i>Recht Ruisseau</i>	779	67 : 25=2-63 : 1	67	60 : 19=3-16 : 1	58 : 58=1-0	1-03 : 1	27 : 28 : 58
<i>Sari Bassin</i>	860	63 : 24=2-62 : 1	58	65 : 23=2-83 : 1	60 : 70=0-86 : 1	1-08 : 1	28 : 33 : 55

*Mesocyclops (Thermocyclops) rylovi* Smirnov.

	Nombre	Moyenne	Valeurs extrêmes
♀ Longueur	17	1022 $\mu$	903—1140 $\mu$
Furca. Long. : larg.	17	3.38 : 1	3.04 : 1—3.60 : 1
Soie dorsale	14	73 $\mu$	38—87 $\mu$
Soie ap. externe	17	73 $\mu$	62—92 $\mu$
Soie ap. méd. ext.	16	244 $\mu$	208—287 $\mu$
Soie ap. interne	17	165 $\mu$	145—183 $\mu$
Soie ap. int. : soie ap. ext.	17	2.24 : 1	1.91 : 1—2.50 : 1
Soie ap. méd. ext. : soie ap. int.	16	1.49 : 1	1.35 : 1—1.69 : 1
Segm. génit. Long. : larg.	15	153.60 : 134.20 = 1.14 : 1	1.02 : 1—1.22 : 1
Art. 3. Enp. 4. Longueur	17	64.8 $\mu$	58—70 $\mu$
Art. 3. Enp. 4. Largeur	17	23.7 $\mu$	22—28 $\mu$
Art. 3. Enp. 4. Long. : larg.	17	2.73 : 1	2.33 : 1—3.09 : 1
Art. 3. Enp. 4. Ep. ap. int.	15	57.2 $\mu$	52—63 $\mu$
Art. 3. Enp. 4. Ep. ap. ext.	15	31.1 $\mu$	27—40 $\mu$
Art. 3. Enp. 4. Ep. ap. int. : ép. ap. ext.	15	1.84 : 1	1.60 : 1—2.18 : 1
Art. 3. Enp. 4. : ép. ap. int.	15	1.13 : 1	1 : 1—1.27 : 1
P 5. Epine	14	64.1 $\mu$	50—73 $\mu$
P 5 Soie apicale	14	50.8 $\mu$	38—60 $\mu$
P 5 Epine : soie ap.	14	1.26 : 1	1 : 1—1.76 : 1
♂ Longueur	11	791 $\mu$	703—931 $\mu$
P 6 Epine	11	38 $\mu$	33—47 $\mu$
P 6 Soie médiane	10	23 $\mu$	20—35 $\mu$
P 6 Soie externe	10	58 $\mu$	50—80 $\mu$
Long. segm. abdom. II	11	57.7 $\mu$	50—67 $\mu$

*Mesocyclops (Thermocyclops) vermifer* Lindberg.

	Nombre	Moyenne	Valeurs extrêmes
♀ Longueur	28	954 $\mu$	779—1074 $\mu$
Furca. Long. : larg.	28	2.91 : 1	2.48 : 1—3.32 : 1
Soie dorsale	27	88 $\mu$	67—113 $\mu$
Soie ap. externe	28	68 $\mu$	52—85 $\mu$
Soie ap. méd. ext.	28	242 $\mu$	220—272 $\mu$
Soie ap. interne	28	187 $\mu$	163—225 $\mu$
Soie ap. int. : soie ap. ext.	28	2.75 : 1	2.32 : 1—3.63 : 1
Soie ap. méd. ext. : soie ap. int.	28	1.28 : 1	1.17 : 1—1.47 : 1
Segm. génit. Long. : larg.	17	140.35 : 107.24 = 1.30 : 1	1.12 : 1—1.58 : 1
Art. 3. Enp. 4. Longueur	27	65.4 $\mu$	58—75 $\mu$
Art. 3. Enp. 4. Largeur	26	20.3 $\mu$	16—25 $\mu$
Art. 3. Enp. Long. : larg.	26	3.21 : 1	2.32 : 1—4 : 1
Art. 3. Enp. 4. Ep. ap. int.	26	64.5 $\mu$	53—70 $\mu$
Art. 3. Enp. 4. Ep. ap. ext.	25	28.3 $\mu$	23—32 $\mu$
Art. 3. Enp. 4. Ep. ap. int. : ép. ap. ext.	25	2.28 : 1	1.89 : 1—2.83 : 1
Art. 3. Enp. 4. : ép. ap. int.	26	1.01 : 1	0.89 : 1—1.23 : 1
P 5. Epine	19	66.8 $\mu$	55—75 $\mu$
P 5 Soie apicale	19	56.1 $\mu$	43—78 $\mu$
P 5 Epine : soie ap.	19	1.19 : 1	0.96 : 1—1.56 : 1
♂ Longueur	13	711 $\mu$	665—808 $\mu$
P 6 Epine	12	31.8 $\mu$	28—37 $\mu$
P 6 Soie mé'iane	11	21.1 $\mu$	13—28 $\mu$
P 6 Soie externe	13	84.3 $\mu$	63—108 $\mu$
Long. segm. abdom. II.	13	51.6 $\mu$	42—62 $\mu$

*M. (Th.) vermifer* Lindberg.*M. (Th.) rylovi*  
Smirnov.

Première antenne rabattue, atteint	24 spéci- mens	Pourcent- age	18 spéci- mens	Pourcent- age
milieu du deuxième segment			4	22.2
bord post. du deuxième segment	5	20.8	11	61.1
commencement du troisième segment	6	25	1	5.6
milieu du troisième segment	8	33.3	2	11.1
bord post. du troisième segment	5	20.8		

*Mesocyclops (Thermocyclops) rylovi* Smirnov. ♀

Localité	Longueur	Furca	Soie dors.	S. ap. m. ext. : s. ap. int.	Exp. 4. Art. 3 Long. : larg.	Exp. 4. Art. 3 Ep. ap. int. : ép. ap. ext.	Exp. 4. Art. 3 : ép. ap. int.	Scap. génit. Long. : larg.	P 5. Art. 2. Epine : soie
<i>Abi Imam</i> Etang d'eau douce.	974	83 : 25 = 3-21 : 1	80	....	63 : 22 = 2-36 : 1	59 : 27 = 2-18 : 1	1-07 : 4	150 : 125 = 1-20 : 1	72 : 53 = 1-36 : 1
	970	80 : 24 = 3-33 : 1	83	239 : 167 = 1-43 : 1	67 : 22 = 3-04 : 1	....	..	150 : 127 = 1-18 : 1	....
	922	77 : 23 = 3-35 : 1	83	239 : 167 = 1-43 : 1	62 : 22 = 2-32 : 1	59 : 23 = 2-10 : 1	1-05 : 1	145 : 123 = 1-18 : 1	63 : 55 = 1-09 : 1
	1026	92 : 28 = 3-54 : 1	67	244 : 173 = 1-41 : 1	67 : 25 = 2-68 : 1	53 : 32 = 1-65 : 1	1-26 : 1	167 : 163 = 1-02 : 1	60 : 43 = 1-30 : 1
<i>Asatou</i> Etang salin	1055	95 : 28 = 3-30 : 1	75	264 : 179 = 1-54 : 1	70 : 25 = 2-30 : 1	55 : 32 = 1-72 : 1	1-27 : 1	163 : 140 = 1-16 : 1	50 : 47 = 1-06 : 1
	1060	82 : 27 = 3-04 : 1	73	244 : 167 = 1-46 : 1	67 : 28 = 2-39 : 1	63 : 35 = 1-30 : 1	1-06 : 1	145 : 128 = 1-13 : 1	70 : 55 = 1-27 : 1
	1007	87 : 25 = 3-43 : 1	..	287 : 170 = 1-60 : 1	67 : 23 = 2-01 : 1	60 : 33 = 1-82 : 1	1-12 : 1	....	68 : 45 = 1-51 : 1
	1140	92 : 28 = 3-29 : 1	75	284 : 181 = 1-57 : 1	63 : 27 = 2-33 : 1	57 : 30 = 1-00 : 1	1-10 : 1	167 : 138 = 1-21 : 1	67 : 60 = 1-12 : 1
<i>Khorranchahr</i> Ruisseau	1007	83 : 23 = 3-60 : 1	75	224 : 147 = 1-52 : 1	63 : 23 = 2-74 : 1	....	..	150 : 137 = 1-09 : 1	67 : 38 = 1-78 : 1
	1050	88 : 25 = 3-52 : 1	87	239 : 160 = 1-40 : 1	65 : 23 = 2-33 : 1	62 : 32 = 1-04 : 1	1-05 : 1	150 : 137 = 1-09 : 1	73 : 55 = 1-33 : 1
	1040	90 : 25 = 3-60 : 1	..	234 : 158 = 1-48 : 1	62 : 22 = 2-32 : 1	60 : 30 = 2 : 1	1-03 : 1	150 : 137 = 1-09 : 1	....
	1045	90 : 27 = 3-33 : 1	75	242 : 153 = 1-53 : 1	68 : 22 = 3-09 : 1	55 : 30 = 1-83 : 1	1-24 : 1	142 : 130 = 1-09 : 1	67 : 50 = 1-34 : 1
<i>Nathi Taqi</i> Etang d'eau douce	1055	95 : 28 = 3-39 : 1	80	264 : 183 = 1-44 : 1	67 : 25 = 2-08 : 1	53 : 33 = 1-60 : 1	1-26 : 1	175 : 143 = 1-22 : 1	58 : 33 = 1 : 1
	1092	88 : 28 = 3-14 : 1	70	250 : 167 = 1-49 : 1	70 : 28 = 2-50 : 1	53 : 40 = 1-45 : 1	1-20 : 1	160 : 137 = 1-17 : 1	58 : 50 = 1-16 : 1
	1026	82 : 23 = 3-56 : 1	..	208 : 150 = 1-39 : 1	58 : 22 = 2-64 : 1	52 : 23 = 1-36 : 1	1-12 : 1	....	....
	993	82 : 24 = 3-42 : 1	63	224 : 145 = 1-54 : 1	63 : 22 = 2-36 : 1	53 : 29 = 1-83 : 1	1-19 : 1	147 : 125 = 1-17 : 1	60 : 50 = 1-29 : 1
<i>Gorgan Mare</i>	903	75 : 23 = 3-26 : 1	38	225 : 167 = 1-36 : 1	60 : 23 = 2-00 : 1	60 : 23 = 2-14 : 1	1 : 1	143 : 123 = 1-16 : 1	65 : 50 = 1-30 : 1



*Mesocyclops (Thermocyclops) rylovi* Smirnov. ♂

Localité	Longueur μ	Furca	Exp. 4. Art. 3. Long. : larg.	Exp. 4. Art. 3. Ep. ap. int. : ép. ap. ext.	Exp. 4. Art. 3 : ép. ap. int.	P 6 Epine : soie méd. : soie ext.	Long. segm. abdom. 2.
<i>Abd Imam</i> Etang d'eau douce Puits.	817	58 : 19=3-05 : 1	62 : 20=3-10 : 1	58 : 30=1-93 : 1	1-07 : 1	38 : 25 : 58	67
	741	62 : 20=3-10 : 1	60 : 17=3-33 : 1	45 : 28=1-60 : 1	1-33 : 1	43 : 22 : 57	50
<i>Assalou</i> Etang salin	741	60 : 18=3-33 : 1	53 : 17=3-12 : 1	45 : 22=2-04 : 1	1-18 : 1	37 : X : 58	50
<i>Dayyir</i> Puits	751	50 : 17=2-94 : 1	..	..	..	33 : 20 : 62	50
<i>Hadakou</i> Puits	827	60 : 18=3-33 : 1	60 : 18=3-33 : 1	52 : 25=2-08 : 1	1-15 : 1	41 : 22 : 53	65
<i>Khorramchahr</i> Ruisseau	931	67 : 23=2-91 : 1	..	..	..	30 : 35 : 80	58
<i>Nakhl Taqi</i> Etang d'eau douce	846	67 : 20=3-35 : 1	50 : 20=2-50 : 1	43 : 27=1-59 : 1	1-16 : 1	42 : 22 : 50	67
<i>Pai tell (Bouchir)</i> Mare de rivière	789	63 : 20=3-15 : 1	56 : 18=3-11 : 1	40 : 27=1-48 : 1	1-40 : 1	47 : 23 : 58	50
<i>Tadjoumelkéh</i> Puits	703	53 : 17=3-12 : 1	52 : 17=3-06 : 1	40 : 26=1-54 : 1	1-30 : 1	33 : 20 : 53	53
	770	62 : 20=3-10 : 1	53 : 17=3-12 : 1	43 : 27=1-59 : 1	1-23 : 1	35 : 20 : 53	52
<i>Recht</i> Ruisseau	789	67 : 20=3-35 : 1	62 : 20=3-10 : 1	43 : 25=1-72 : 1	1-44 : 1	42 : 22 : X	63

*Mesocyclops (Thermocyclops) vermifer* Lindberg. ♀

Localité	Longueur μ	Furca	Sole dors.	S. ap. m. ext.: s. ap. int.	Emp. 4. Art. 3. Long. : larg.	Emp. 4. Art. 3. Ep. ap. int.: Ep. ap. ext.	Emp. 4. Art. 3. Ep. ap. int.	Segm. génit. Long. : larg.	P 5. Art. 2. Epine : sole
<i>Akasz</i> Bassin	1007 969 1022	73 : 23-3-17 : 1 78 : 23-3-32 : 1 70 : 23-3-04 : 1	88 87 92	270 : 212=1-27 : 1 250 : 203=1-23 : 1 237 : 207=1-24 : 1	63 : 21=3 : 1 63 : 22=2-56 : 1 62 : 21=2-95 : 1	58 : 26=2-23 : 1 60 : 23=2-60 : 1 63 : 23=2-83 : 1	1-09 : 1 1-05 : 1 0-95 : 1	142 : 105=1-35 : 1 142 : 107=1-33 : 1 142 : 107=1-33 : 1	70 : 50=1-40 : 1 67 : 58=1-16 : 1 63 : 53=1-19 : 1
<i>Ak (Outh)</i> Puits	893 946	63 : 23=2-56 : 1 63 : 22=2-86 : 1	83 87	234 : 189=1-24 : 1 220 : 179=1-23 : 1	75 : 20=3-25 : 1 75 : 20=3-75 : 1	53 : 23=1-89 : 1 67 : 30=2-23 : 1	1-23 : 1 1-12 : 1	158 : 108=1-48 : 1 ..	67 : 43=1-56 : 1 ..
<i>Balbhara</i> Bassin	922	63 : 22=3-09 : 1	93	242 : 183=1-34 : 1	64 : 16=4 : 1	60 : 30=2 : 1	1-07 : 1	133 : 103=1-23 : 1	63 : 50=1-26 : 1
<i>Citerne</i>	960 903	67 : 23=2-91 : 1 67 : 23=2-91 : 1	77 100	250 : 179=1-39 : 1 229 : 184=1-24 : 1	63 : 18=3-50 : 1 62 : 20=3-10 : 1	60 : 30=2 : 1 60 : 23=2-14 : 1	1-05 : 1 1-03 : 1	132 : 108=1-31 : 1 125 : 100=1-25 : 1	63 : 53=1-19 : 1 63 : 55=1-13 : 1
Puits à l'eau saumâtre	950	67 : 24=2-79 : 1	100	234 : 185=1-26 : 1	62 : 20=3-10 : 1	68 : 33=2-06 : 1	0-91 : 1	140 : 97=1-44 : 1	67 : 50=1-84 : 1
<i>Galléhar</i> Réservoir	865 893 1055	63 : 20=3-15 : 1 63 : 23=2-05 : 1 75 : 23=3-26 : 1	100 100 113	225 : 175=1-29 : 1 267 : 225=1-19 : 1	63 : 18=3-50 : 1 62 : 20=3-10 : 1 68 : 20=3-40 : 1	67 : 25=2-68 : 1 65 : 27=2-40 : 1 68 : 23=2-72 : 1	0-94 : 1 0-95 : 1 1 : 1	132 : 100=1-32 : 1 137 : 100=1-37 : 1	70 : 67=1-04 : 1 75 : 78=0-96 : 1
<i>Pourth</i> Puits	1064 1016 1079 1074	67 : 27=2-48 : 1 63 : 23=2-52 : 1 67 : 23=2-91 : 1 67 : 23=2-63 : 1	83 67 75 73	239 : 163=1-47 : 1 250 : 170=1-29 : 1 254 : 184=1-38 : 1 229 : 174=1-32 : 1	70 : 25=2-80 : 1 70 : 22=3-18 : 1 67 : 21=3-19 : 1 68 : 20=3-40 : 1	67 : 32=2-06 : 1 68 : 33=2-12 : 1 67 : 29=2-24 : 1 65 : 31=2-09 : 1	1-04 : 1 1-03 : 1 1-03 : 1 1-05 : 1	143 : 113=1-26 : 1 142 : 120=1-18 : 1 143 : 113=1-24 : 1	67 : 67=1 : 1 67 : 50=1-34 : 1 70 : 58=1-20 : 1 ..
<i>Tahiri</i> Réservoir	893 922 1012 941 893 1055	65 : 23=2-95 : 1 62 : 23=2-82 : 1 82 : 23=2-58 : 1 57 : 23=2-50 : 1 58 : 23=2-64 : 1 63 : 26=2-62 : 1	82 92 88 83 70 87	240 : 184=1-30 : 1 239 : 192=1-24 : 1 235 : 190=1-24 : 1 .. 232 : 190=1-22 : 1	65 : 18=3-61 : 1 65 : 18=3-61 : 1 73 : 22=3-22 : 1 67 : 18=3-72 : 1 58 : 25=2-32 : 1 73 : 23=3-17 : 1	63 : 30=2-10 : 1 59 : 23=2-10 : 1 70 : 23=2-41 : 1 67 : 23=2-39 : 1 68 : 30=2-27 : 1	1-03 : 1 1-10 : 1 1-04 : 1 1 : 1 1-07 : 1	132 : 103=1-28 : 1 .. .. .. 137 : 122=1-12 : 1	67 : 58=1-16 : 1 .. .. 55 : 47=1-17 : 1 70 : 50=1-40 : 1
Puits à l'eau douce	950	65 : 24=2-70 : 1	88	250 : 194=1-29 : 1	71 : 20=3-55 : 1	67 : 33=2-06 : 1	1-06 : 1	163 : 103=1-58 : 1	67 : 50=1-34 : 1
<i>Tang-Qil</i> Réservoir	912 855 779	67 : 23=2-91 : 1 63 : 20=3-15 : 1 82 : 20=3-10 : 1	100 100 ..	250 : 202=1-24 : 1 247 : 197=1-25 : 1 220 : 167=1-32 : 1	62 : 20=3-10 : 1 60 : X=X : 1 ..	65 : 30=2-17 : 1 67 : X=X : 1 ..	0-95 : 1 0-89 : 1 ..	130 : 107=1-21 : 1 .. ..	67 : 63=1-06 : 1 .. ..
<i>Sari</i> Bassin	941 950	68 : 23=2-95 : 1 68 : 22=3-09 : 1	90 88	272 : 194=1-40 : 1 234 : 200=1-17 : 1	63 : 20=3-15 : 1 64 : 22=2-91 : 1	70 : 28=2-60 : 1 67 : 25=2-68 : 1	0-90 : 1 0-96 : 1	145 : 107=1-36 : 1 ..	75 : 67=1-12 : 1 ..

*Mesocyclops (Thermocyclops) vermifer* Lindberg. ♂

Localité	Longueur μ	Furca	Enp. 4. Art. 3. Long. : larg.	Enp. 4. Art. 3. Ep. ap. int. : ép. ap. ext.	Enp. 4. Art. 3. : ép. ap. int.	P 6 Epine : soie méd. : soie ext.	Long. segm. abdom. 2.
<i>Ahvaz</i> Bassin	808	48 : 17=2-82 : 1	50 : 16=3-12 : 1	..	..	27 : 17 : 100	50
<i>Alk (Oult)</i> Puits	665	38 : 16=2-37 : 1	55 : 16=3-44 : 1	43 : 20=2-15 : 1	1-28 : 1	35 : 25 : 83	53
<i>Bébbéhan</i> Bassin	751	50 : 19=2-63 : 1	55 : 16=3-44 : 1	53 : 24=2-21 : 1	1-04 : 1	33 : 28 : 97	62
Citerne	665	..	48 : 13=3-69 : 1	48 : X=X : 1	1 : 1	30 : 23 : 100	50
<i>Galléhdar</i> Réservoir	732	47 : 17=2-76 : 1	55 : 15=3-67 : 1	55 : 20=2-75 : 1	1 : 1	37 : 22 : 108	55
<i>Parak</i> Etang salin	675	42 : 17=2-47 : 1	53 : 14=3-78 : 1	50 : 22=2-27 : 1	1-06 : 1	30 : 17 : 70	47
<i>Pouzé</i> Puits	713	40 : 18=2-22 : 1	58 : 15=3-87 : 1	45 : 22=2-04 : 1	1-29 : 1	X : X : 83	57
	751	40 : 18=2-22 : 1	55 : 17=3-24 : 1	..	..	28 : 13 : 67	42
<i>Tahiri</i> Réservoir	684	42 : 17=2-47 : 1	53 : 17=3-12 : 1	44 : 20=2-20 : 1	1-20 : 1	35 : 20 : 63	50
Puits à l'eau douce	665	38 : 15=2-53 : 1	..	..	..	33 : 21 : 67	50
<i>Tahiri-Nakhl Taqi</i> Puits à l'eau douce	713	45 : 19=2-37 : 1	..	..	..	28 : X : 77	55
<i>Sari</i> Bassin	703	43 : 17=2-53 : 1	56 : 16=3-25 : 1	48 : 20=2-40 : 1	1-17 : 1	33 : 25 : 90	50
	722	..	..	..	..	33 : 22 : 92	50

*Mesocyclops (Thermocyclops) microspinulosus*, sp. nov.

Longueur μ	Furca Long. : Larg.	Furca Soie dorsale	Furca Soies apicales	Art. 3. Enp. 4. Long. : larg.	Art. 3. Enp. 4. Ep. ap. int. : ép. ap. ext.	Long. art. 3 Enp. 4 : ép. ap. int.
♀ 1188	(59+28) : 32=2.72 : 1	75	97 : 259 : 312 : 208	60 : 27=2.22 : 1	62 : 33=1.89 : 1	0.97 : 1
♀ 1178	(67+25) : 27=3.40 : 1	75	83 : 282 : 332 : 195	70 : 23=3.04 : 1	60 : 35=1.71 : 1	1.17 : 1
♀ 1306	(62+33) : 32=2.97 : 1	72	83 : 251 : 293 : 183	..	..	..
♀ 1197	(69+28) : 31=3.13 : 1	87	93 : 264 : 320 : 202	67 : 28=2.39 : 1	63 : 35=1.80 : 1	1.06 : 1
♂ 946	(42+20) : 22=2.82 : 1	68	53 : 200 : 242 : 175	58 : 19=3.05 : 1	48 : 28=1.71 : 1	1.20 : 1

	Sad.		Plateau et Est.		Provinces Caspiennes.		Total.	
	Stations.	Habitata.	Stations.	Habitata.	Stations.	Habitata.	Stations.	Habitata.
<i>Haliocyclops thermophilus spinifer</i> Kiefer	1	1	..	..	..	..	1	1
<i>Macrocyclops fuscus</i> Jurine	..	..	..	..	..	3	1	3
<i>Macrocyclops albidus</i> Jurine	..	..	2	2	3	8	5	10
<i>Eucyclops serrulatus</i> (Fischer)	7	15	18	38	9	28	34	81
<i>Eucyclops agioides</i> Sars	..	..	1	1	..	..	1	1
<i>Eucyclops euacanthus</i> Sars	..	..	2	2	..	..	2	2
<i>Eucyclops macruroides</i> (Lilljeborg)	..	..	..	..	1	1	1	1
<i>Eucyclops farsicus</i> Lindberg	..	..	1	1	..	..	1	1
<i>Eucyclops ruthneri elburziensis</i> Lindberg	..	..	3	5	..	..	3	5
<i>Tropocyclops prasinus</i> (Fischer)	..	..	1	1	..	..	1	1
<i>Tropocyclops confinis</i> Kiefer	..	..	4	4	..	..	4	4
<i>Paracyclops fimbriatus</i> (Fischer)	2	2	2	3	..	..	4	5
<i>Paracyclops vagus</i> Lindberg	1	1	1	1	4	7	6	9
<i>Ectocyclops phaleratus</i> (Koch)	..	..	1	1	..	..	1	1
<i>Ectocyclops rubescens</i> Brady	1	2	2	2	3	8	6	12
<i>Cyclops strenuus divergens</i> Lindberg	2	7	9	21	3	3	14	31
<i>Cyclops caespicus</i> Lindberg	..	..	..	..	1	3	1	3
<i>Cyclops kozminskii</i> Lindberg	..	..	..	..	1	1	1	1
<i>Megacyclops viridis</i> Jurine	3	8	7	9	12	40	22	57
<i>Acanthocyclops vernalis</i> Fischer	..	..	..	..	5	9	5	9

	Sud.		Plateau et Est.		Provinces Caspiennes.		Total.	
	Stations.	Habitats.	Stations.	Habitats.	Stations.	Habitats.	Stations.	Habitats.
<i>Acanthocyclops robustus</i> Sars	..	2.	..	5	..	8	3	6
<i>Acanthocyclops bicuspidatus</i> Claus	..	..	..	..	14	37	20	47
<i>Acanthocyclops bicuspidatus odessanus</i> Chmankévitch.	7	10	1	1	1	2	9	13
<i>Acanthocyclops biestosus</i> Rehberg	2	2	1	1	8	20	11	23
<i>Microcyclops varicans</i> Sars	3	5	4	4	6	12	13	21
<i>Microcyclops richardi</i> Lindberg	..	..	..	..	1	1	1	1
<i>Microcyclops moghulensis</i> Lindberg	..	..	1	1	..	..	1	1
<i>Microcyclops bicolor</i> Sars	..	..	1	1	..	..	1	1
<i>Microcyclops linjanicus</i> Kiefer	1	1	3	3	4	5	8	9
<i>Metacyclops minutus</i> Claus	34	54	13	32	1	1	48	87
<i>Metacyclops grandispinifer</i> Lindberg	6	6	3	3	..	..	9	10
<i>Metacyclops planus</i> Gurney	7	12	2	2	3	6	12	20
<i>Apocyclops dengizicus</i> Lepechkin	3	3	..	8	..	..	3	3
<i>Meocyclops leuckartii</i> Claus	20	29	..	..	8	16	36	65
<i>Thermocyclops dybowskii</i> Lande	..	..	1	1	2	2	3	3
<i>Thermocyclops hyalinus</i> (Rehberg)	..	..	1	1	..	..	1	1
<i>Thermocyclops tylosi</i> Smirnov	9	12	1	1	2	2	12	15
<i>Thermocyclops microspinulosus</i> Lindberg	1	1	..	..	..	..	1	1
<i>Thermocyclops vermifer</i> Lindberg	11	16	3	5	3	3	17	24
<i>Thermocyclops tinctus</i> Lindberg	1	1	6	7	..	..	7	8

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## ON TWO HELMINTHS OF *MASTACEMBELUS PANCALUS* (HAM.)

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Dr. Bains Prashad, Director, Zoological Survey of India, kindly provided the author with the opportunity of examining two helminths obtained from the freshwater spiny eel, *Mastacembelus pancalus* (Ham.), taken at Fuleshwar, B. N. Ry.

### *Azygia angusticauda* (Stafford, 1904).

This is the first record of a member of the trematode genus *Azygia* from India. Three specimens were available for study and they were stated to have been found wriggling on the liver of the host. As observed by Van Cleave and Mueller (1934), *Azygia angusticauda* shows considerable variations in its organization. A few observations on the anatomy of the specimens before the author are recorded below.

The worms are flat and elongate, with both extremities rounded. They measure 3.63–4.5 mm. in length and 0.865–0.875 mm. in maximum breadth, which is attained in the region of the midbody. The cuticle is devoid of any armature. The oral sucker is subterminal and measures 0.38–0.47 × 0.34–0.45 mm. The ventral sucker measures 0.36–0.465 mm. in diameter and is situated at about the anterior third of the body. There is no pre-pharynx. The pharynx is situated immediately behind the oral sucker and measures about 0.1 mm. in diameter. The oesophagus is very short. The intestinal caeca pass posteriorly along the sides of the body and terminate slightly in front of the anterior end. The excretory bladder is tubular.

The testes are round or somewhat oblong bodies, lying diagonally to one another, at a small distance in front of the posterior end of the body. They measure 0.24–0.45 × 0.172–0.23 mm. In one instance, the posterior testis was much atrophied and measured 0.135 × 0.07 mm. The genital pore is situated centrally, midway between the intestinal fork and the ventral sucker. The genital sinus is very spacious. The cirrus sac measures 0.28–0.33 × 0.19–0.22 mm. and encloses the vesicula seminalis, the pars prostatica and the ductus ejaculatorius. The prostate gland cells surround the vesicula seminalis and the pars prostatica and fill up the cirrus sac completely.

The ovary is somewhat kidney-shaped and lies partially lateral to the anterior testis. It measures 0.28–0.327 × 0.13–0.24 mm. and is situated slightly to the side of the middle line. The shell gland measures 0.22–0.27 × 0.12–0.18 mm. and lies centrally, immediately in front of the ovary. There is no receptaculum seminis but Laurer's canal is present. The vitelline glands, consisting of follicles of moderate size, lie along the sides of the body external to the intestinal caeca and extend from the posterior end to some distance behind the ventral



sucker, commencing 1.92—2.3 mm. from the anterior end. A vitelline reservoir measuring  $0.07-0.18 \times 0.03-0.08$  mm. lies immediately behind or to the side of the shell gland. The uterine coils are disposed transversely and lies centrally between the ovary and the posterior border of the ventral sucker. The metraterm lies either lateral or dorsal to the ventral sucker and opens into the genital sinus. The eggs measure  $0.062-0.078 \times 0.04-0.048$  mm.

### **Gnathostoma sp.**

One encysted larva of *Gnathostoma* sp. was found in the liver of the fish. It is probable that the larva belongs to the species *G. spinigerum*, for this species occurs commonly in cats and dogs in India. According to Chandler (1925), this is the deadliest of the parasites of cats in Calcutta. The first intermediate host of this roundworm is known to be a species of *Cyclops*, and advanced larvae have been found encysted in various reptiles and birds. This is the first record of a fish acting as a second intermediate host of this parasite.

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# A LIST OF FISHES OF THE MYSORE STATE AND OF THE NEIGHBOURING HILL RANGES OF THE NILGIRIS, WYNAAD AND COORG.

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In a recent article entitled "The Fishes of Mysore State", Bhimachar and Subba Rau<sup>1</sup> have given an account of the fishes of the Kadur District and have briefly referred to the earlier works on the ichthyology of this part of the Deccan plateau. A general account of the physical features of the State is given and remarks are offered on the zoogeographical significance of the occurrence in Mysore of certain Malayan species. The authors propose to make a detailed systematic study of the fishes found in different parts of the State and the results are to be published from time to time as and when the reports are ready.

The authors have published valuable observations on *Silurus cochinchinensis* Cuvier & Valenciennes; it is a very variable, loach-like Silurid which lives at the bottom of shallow, rocky streams and is widely distributed from Cochin-China, Southern China, Siam, Malay Peninsula, Burma, Assam Hills, Eastern Himalayas, Mysore and the Wynaad Hills. In recording this species from Mysore for the first time, the authors have adduced evidence to show that *S. wynaadensis* Day, a species which was distinguished by the presence of 4 barbles, is the same as *S. cochinchinensis*, normally with two barbles in the adult state.

With a view to help in the survey of the fish-fauna of the State, I give below a systematic list of the species so far known from Mysore and the adjoining hill-ranges of the Nilgiris, Wynaad and Coorg, along with their respective areas of distribution.

## LIST<sup>2</sup> OF THE FISHES OF MYSORE AND OF THE ADJOINING HILL RANGES.

The general classification of fishes adopted in the list is that proposed by Dr. C. Tate Regan, F.R.S., in his article on 'Fishes' in the

<sup>1</sup> Bhimachar, B. S. and Subba Rau, A. *Journ. Mysore Univ.* (B) I, pp. 141-153, 1 map, 1 text-fig. and 2 pls. (1941).

<sup>2</sup> In drawing up this list, recent records of fishes from Mysore have been consulted as well as Day's *Fishes of India* and his two volumes on 'Fishes' in the *Fauna of British India* series. The enumeration of species is, however, not based on actual examination of specimens.

In connection with the geographical distribution of the various species, the following works were consulted:—1. Suvatti, C., *Index to Fishes of Siam*, (Bangkok, 1936); 2. Fowler, H. W., 'A List of Fishes known from Malaya.' *Fisheries Bull. Singapore*, No. 1 (1938); 3. Weber, M. and Beaufort L. F. de, *The Fishes of the Indo-Australian Archipelago* (Leiden, 1913-1936); 4. Chu, Y. T., 'Index Piscium Sinensium.' *Biol. Bull. St. John's Univ.* No. 1 (1931); 5. Chabanaud, P., 'Inventaire de la faune ichtyologique de l'Indochine. Première Liste.' *Service Oceanographique des peches de l'Indochine*, Note 1 (1926); and 6. Chevey, P., 'Inventaire de la faune ichtyologique de l'Indochine. Deuxième Liste.' *Inst. Oceanographique de l'Indochine*, Note 19. (1932).

Fourteenth Edition of the Encyclopaedia Britannica (1929). The genera under their respective families and the species under each genus are alphabetically arranged.

*Names of Species.*

*Geographical Range.*

Order : ISOSPONDYLI.

Family : NOTOPTERIDAE.

1. *Notopterus notopterus* (Pallas).. India, Burma and further east.

Family : CLUPEIDAE.

2. *Hilsa ilisha* (Ham.) .. .. Persian Gulf and coasts of India and Burma ; it ascends principal rivers.

Order : OSTARIOPHYSI.

Suborder : CYPRINOIDEA.

Family : CYPRINIDAE.

Subfamily : ABRAMADINAE.

3. *Chela argentea* Day .. .. Nilgiris, Coorg and Mysore. Also found at Calcutta.  
 4. *Chela baicala* Ham. .. .. Throughout India (except Malabar), and Burma.  
 5. *Chela clupcoides* (Bloch) .. Cutch, Peninsular India and Satpura Trend.  
 6. *Chela phulo* Ham. .. .. Assam, Bengal, Orissa, Central Provinces and the Deccan as far as the Kistna.  
 7. *Laubuca atpar* (Ham.) .. India and Burma.

Subfamily : RASBORINAE.

8. *Barilius barila* Ham. .. .. Northern India as far as the Kistna and Burma.  
 9. *Barilius barna* Ham. .. .. Northern India as far as the Kistna and Burma.  
 10. *Barilius bendelisis* Ham. .. Throughout India. Day's records from Ceylon requires confirmation.  
 11. *Barilius canarensis* (Jerd.) .. Western Ghats of Malabar, Canara and Mysore.  
 12. *Barilius gutensis* (C. V.) .. Western Ghats of Malabar, Nilgiris, Coorg, Mysore and Travancore.  
 13. *Barilius vagra* Ham. .. .. Northern India as far as the Kistna. Day's record from Ceylon requires confirmation.  
 14. *Brachydanio rerio* (Ham.) .. India and Burma.  
 15. *Danio aequipinnatus* (McClell.)<sup>1</sup> Ceylon, India, Burma and Siam.  
 16. *Esomus barbatus* (Jerd.) .. Peninsular India.  
 17. *Rasbora caverii* (Jerd.).. Coorg and Mysore State.  
 18. *Rasbora daniconius* (Ham.) .. Ceylon, India, Burma and further east.  
 19. *Rasbora rasbora* (Ham.) India, Burma and further east.

Subfamily : CYPRININAE.

20. *Amblypharyngodon melettina*  
 (C. V.) .. .. Ceylon and Peninsular India.  
 21. *Amblypharyngodon microlepis*  
 (C. V.) .. .. Peninsular India, through Orissa to Calcutta.  
 22. *Amblypharyngodon mola* (Ham.) India, except Malabar, and Burma.  
 23. *Barbus* (*Puntius*) *amphibius*  
 (C. V.) .. .. Ceylon and Peninsular India.

<sup>1</sup> Hora and Nair have recently shown (*Rec. Ind. Mus.* XLIII, p. 371, 1941) that *Danio strigillifer* Myers and *D. malabaricus* (Jerdon) are synonymous with *D. aequipinnatus* (McClelland).

<i>Names of Species.</i>	<i>Geographical Range.</i>
24. <i>Barbus (Puntius) carnaticus</i> (Jerd.) .. ..	Nilgiris, Wynad, Mysore and S. Canara.
25. <i>Barbus (Puntius) chola</i> Ham.	India, Burma and further east.
26. <i>Barbus (Puntius) dorsalis</i> (Jerd.) <sup>1</sup> .. ..	Peninsular India and Ceylon.
27. <i>Barbus (Puntius) dubius</i> Day ..	Nilgiris and Mysore.
28. <i>Barbus (Puntius) filamentosus</i> (C. V.) <sup>2</sup> .. ..	Ceylon and Peninsular India.
29. <i>Barbus (Puntius) jerdoni</i> Day <sup>3</sup>	Deccan and Canara below the Ghats ; its record from Malaya needs confirmation.
30. <i>Barbus (Puntius) kolus</i> Sykes ..	Deccan and Central Provinces.
31. <i>Barbus (Puntius) lithophilus</i> Day .. ..	Coorg, Mysore, S. Canara and Travancore.
32. <i>Barbus (Puntius) melanampyx</i> (Day) .. ..	Peninsular India.
33. <i>Barbus (Puntius) micropogon</i> (C. V.) .. ..	Nilgiris, Wynad, Mysore, S. Canara and Travancore.
34. <i>Barbus (Puntius) narayani</i> Hora .. ..	Coorg and Mysore.
35. <i>Barbus (Puntius) neilli</i> Day ..	Mysore and Deccan. Its record from Malaya needs confirmation.
36. <i>Barbus (Puntius) parrah</i> (Day)	Peninsular India.
37. <i>Barbus (Puntius) pleurotaenia</i> Blkr. .. ..	Ceylon and Mysore.
38. <i>Barbus (Puntius) pulchellus</i> Day .. ..	Mysore.
39. <i>Barbus (Puntius) sarana</i> (Ham.) <sup>5</sup> .. ..	Ceylon, India and Burma. It has also been recorded from China.
40. <i>Barbus (Puntius) sophore</i> Ham. <sup>6</sup> .. ..	India, Burma and Yunnan.
41. <i>Barbus (Puntius) ticto</i> Ham. <sup>7</sup>	Ceylon, India, Burma and Siam.
42. <i>Barbus (Puntius) vittatus</i> (Day) .. ..	Cutch, Peninsular India and Ceylon.
43. <i>Barbus (Tor) khudree</i> Sykes <sup>4</sup> ..	Ceylon, Peninsular India, Deccan and Satpura Trend.
44. <i>Catla catla</i> (Ham.) .. ..	Northern India as far as the Kistna and Burma. Introduced into the Cauvery.
45. <i>Cirrhitina cirrhosa</i> (Bloch) ..	Southern India generally.
46. <i>Cirrhitina fulungee</i> (Sykes) ..	Deccan and Mysore.

<sup>1</sup> *Puntius puckelli* Day is a synonym of *Puntius dorsalis* (Jerdon) ; vide Hora, S. L., *Rec. Ind. Mus.* XXXVIII, p. 2 (1936).

<sup>2</sup> *Barbus (Puntius) mahecola* (C. V.) is the female of *B. (Puntius) filamentosus* (C. V.) ; vide Hora, S. L., *Rec. Ind. Mus.* XXXIX, pp. 22-24 (1937).

<sup>3</sup> *Barbus Dobsoni* Day (*Fish. India*, p. 568, 1878) is a synonym of *B. jerdoni* Day.

<sup>4</sup> For a description of *Barbus khudree* Sykes see Hora and Misra in *Journ. Bombay Nat. Hist. Soc.* XL, pp. 24-28 (1938). Taxonomy of this species will be discussed in my series of articles on the "Game Fishes of India".

<sup>5</sup> *Barbus chrysopoma* C.V. and *B. pinnauratus* (Day) are synonyms of *Barbus sarana* (Ham.).

<sup>6</sup> *Barbus (Puntius) stigma* (Cuv. & Val.) of authors is synonymous with *B. (Puntius) sophore* Ham. ; vide Chaudhuri, *Mem. Ind. Mus.* V, p. 436 (1916).

<sup>7</sup> *Barbus punctatus* Day from Peninsular India and *B. stoliczkanus* Day from Burma characterised by the presence of a complete lateral line are synonymous with *B. ticto* ; vide Hora, Misra and Malik, *Rec. Ind. Mus.* XLI, p. 263 (1939).

Names of Species.	Geographical Range.
47. <i>Cirrhina reba</i> (Ham.) .. ..	Throughout India. Its record from Indo-china requires confirmation.
48. <i>Garra bicornuta</i> Rao .. ..	Mysore.
49. <i>Garra jerdoni</i> Day .. ..	Nilgiris, Wynaad and Mysore.
50. <i>Garra mullya</i> (Sykes) .. ..	Kathiawar, Peninsular India and Satpura Trend.
51. <i>Garra stenorhynchus</i> (Jerd.) .. ..	Nilgiris, Coorg and Mysore.
52. <i>Labeo ariza</i> (Ham.) .. ..	Nilgiris, Wynaad and Mysore.
53. <i>Labeo boga</i> (Ham.) .. ..	India and Burma.
54. <i>Labeo boggut</i> (Sykes) .. ..	Central and south-west India. Its record from Malaya requires confirmation.
55. <i>Labeo calbasu</i> (Ham.) .. ..	India and Burma. It has been recorded from China also.
56. <i>Labeo dussumieri</i> (C. V.) .. ..	Ceylon, South Malabar and Mysore.
57. <i>Labeo fimbriatus</i> (Bloch) .. ..	Sind, Punjab, the Deccan and Southern India to Orissa. Not recorded from Malabar.
58. <i>Labeo kaurus</i> (Sykes) .. ..	Poona and the Deccan.
59. <i>Labeo kontius</i> (Jerd.) .. ..	Nilgiris and Mysore.
60. <i>Labeo polail</i> (Sykes) .. ..	Mysore, Deccan and Ceylon.
61. <i>Mystacoleucus ogilbii</i> (Sykes) .. ..	Mysore and Deccan.
62. <i>Oreichthys cosuatus</i> (Ham.) .. ..	India, Burma and Siam.
63. <i>Osteochilus</i> ( <i>Kantaka</i> ) <i>brevidor-</i> <i>salis</i> (Day) .. ..	Nilgiris and Mysore.
64. <i>Osteochilus</i> ( <i>Osteochilichthys</i> ) <i>nashii</i> (Day) .. ..	Coorg, Wynaad, S. Canara and Mysore.
65. <i>Osteochilus</i> ( <i>Osteochilichthys</i> ) <i>thomassi</i> (Day) .. ..	South Canara and Mysore.
66. <i>Rohitee colio</i> var. <i>cunma</i> Day .. ..	Sind, Deccan, Orissa, Assam and Burma.
67. <i>Rohitee neilli</i> Day .. ..	Deccan, Mysore and Travancore.
68. <i>Schismatorhynchus</i> ( <i>Nukta</i> ) <i>nukta</i> (Sykes) .. ..	Mysore and Deccan.
Family : HOMALOPTERIDAE.	
69. <i>Bharania australis</i> (Jerd.) <sup>1</sup> .. ..	Malabar, Wynaad, Nilgiris, Mysore and Travancore.
70. <i>Balitora brucei</i> var. <i>mysorensis</i> Hora .. ..	Mysore.
Family : COBITIDAE.	
71. <i>Bolia striata</i> Rao .. ..	Mysore.
72. <i>Lepidocephalus thermalis</i> (C. V.) .. ..	Ceylon and Peninsular India.
73. <i>Nemachilichthys shimoyensis</i> Rao .. ..	Mysore.
74. <i>Nemachilus anguilla</i> (Annan.) .. ..	Yenna River at Mehda, Satara Dist., and Thunga River at Shimoga, Mysore.
75. <i>Nemachilus bhimachari</i> Hora .. ..	Mysore.
76. <i>Nemachilus botia</i> (Ham.) .. ..	Ceylon, India and Burma.
77. <i>Nemachilus dayi</i> Hora .. ..	Deccan and the Satpura Trend.
78. <i>Nemachilus denisonii</i> Day .. ..	Deccan, Nilgiris, Coorg and Mysore.
79. <i>Nemachilus erezardi</i> Day .. ..	Deccan, Satpura Trend and Peninsular India.
80. <i>Nemachilus monilis</i> Hora .. ..	Nilgiris and Mysore.
81. <i>Nemachilus semiarmatus</i> Day .. ..	Nilgiris and Mysore.
82. <i>Nemachilus sinuatus</i> Day .. ..	Wynaad and Mysore.
83. <i>Nemachilus striatus</i> Day .. ..	Wynaad, Nilgiris and Mysore.

<sup>1</sup> *Bharania annandalei* Hora is synonymous with *B. australis* (Jerdon); vide Hora, Rec. Ind. Mus. XLIII, p. 225 (1941).

*Names of Species.**Geographical Range.*

## Suborder : SILUROIDEA.

## Family : CLARIIDAE.

84. *Clarias batrachus* (Linn.) .. India, Burma and further east.

## Family : HETEROPNEUSTIDAE.

85. *Heteropneustes fossilis* (Bloch) Ceylon, India, Burma and further east.

## Family : SILURIDAE.

86. *Callichrous bimaculatus* (Bloch) Ceylon, India, Burma and further east.

87. *Silurus cochinchinensis* C. V. .. Wynnaad, Mysore, Eastern Himalayas, Assam Hills, Burma and further east.

88. *Wallagonia attu* (Bloch) .. Ceylon, India, Burma and further east.

## Family : SCHILBEIDAE.

89. *Proeutropiichthys taakree* (Sykes)<sup>1</sup> .. .. Peninsular India, except Malabar.

90. *Pseudeutropius atherinoides* (Bloch) .. .. India and Burma.

91. *Silonopangasius childrenii* (Sykes) .. .. Deccan Western Ghats near Poona to Mysore.

## Family : BAGRIDAE.

92. *Mystus aor* (Ham.) .. .. India, Burma and China.

93. *Mystus curasius* (Ham.) .. India, Burma and further east.

94. *Mystus kelutius* (C. V.) .. Ceylon and Peninsular India.

95. *Mystus malabaricus* (Jerd.) .. Wynnaad, Mysore, Malabar and Travancore.

96. *Mystus montanus* (Jerd.) .. Wynnaad, Coorg, Mysore and Travancore.

97. *Mystus oculatus* (C. V.) .. Nilgiris, Mysore, Malabar and Travancore.

98. *Mystus punctatus* (Jerd.) .. Nilgiris and Mysore.

99. *Mystus vittatus* (Bloch) .. Ceylon, India, Burma and Siam.

100. *Rita hastata* Val. .. .. Deccan and Mysore.

## Family : SISORIDAE.

101. *Bagarius bagarius* (Ham.) .. India, Burma and further east.

102. *Gagata itchkkea* (Sykes) .. Northern parts of Western Ghats and Coorg.

103. *Glyptothorax tonah* (Sykes) .. Deccan and the Satpura Trend.

104. *Glyptothorax madsratanus* (Day) .. .. Nilgiris, Mysore and Travancore.

## Order : APODES.

## Family : ANGUILLIDAE.

105. *Anguilla bengalensis* Gray .. Ceylon, India, Burma and further east.

## Order : SYNENTOGNATHI.

## Suborder : SCOMBRESOCOIDEA.

## Family : XENENTODONTIDAE.

106. *Xenentodon cancila* (Ham.) .. Ceylon, India, Burma and further east.

## Order : MICROCYPRINI.

## Family : CYPRINODONTIDAE.

107. *Aplocheilus blockii* (Arnold) .. Ceylon and Peninsular India.

108. *Aplocheilus lineatus* (C. V.) .. Ceylon and Peninsular India.

109. *Oryzias melanostigma* (McClell.) .. .. Peninsular India, Orissa, Lower Bengal and Burma.

<sup>1</sup> *Schilbe sykesii* Jerdon, *Eutropius microphthalmus* Blyth, *Pseudeutropius megalops* Günther and *P. longimanus* Günther are synonymous with *Proeutropiichthys taakree* Sykes; vide Hora, *Rec. Ind. Mus.* XLIII, p. 106 (1941).

## Names of Species.

## Geographical Range.

## Order : PERCOMORPHI.

## Suborder : PERCOIDEA.

## Family : AMBASSIDAE.

110. *Ambassis nama* (Ham.) .. India and Burma.  
 111. *Ambassis rangi* (Ham.) .. India, Burma and further east.

## Family : CICHLIDAE.

112. *Etroplus suratensis* (Bloch) .. Ceylon and Peninsular India.

## Suborder : GOBIOIDEA.

## Family : GOBIIDAE.

113. *Glossogobius giuris* (Ham.) .. Ceylon, India, Burma and further east.

## Suborder : ANABANTOIDEA.

## Family : POLYCANTHIDAE.

114. *Macropodus cupanus* C. V. .. South India, Malay Peninsula and Sumatra.

## Suborder : OPHICEPHALOIDEA.

## Family : OPHICEPHALIDAE.

115. *Ophicephalus gachua* Ham. .. Ceylon, India, Burma and further east.  
 116. *Ophicephalus leucopunctatus*  
     Sykes .. .. . Peninsular India and Deccan.  
 117. *Ophicephalus marulius* Ham. Ceylon, India, Burma and further east.  
 118. *Ophicephalus punctatus* Bloch India, Burma and Malaya.  
 119. *Ophicephalus striatus* Bloch .. Ceylon, India, Burma and further east.

## Order : OPISTHOMI.

## Family : MASTACEMBEIIDAE.

120. *Mastacembelus armatus* (Lacép.) Ceylon, India, Burma and further east.  
 121. *Mastacembelus pancalus* (Ham.) Northern India generally: its records from south of Kistna are few.

It will be seen from the above that in the fish fauna of Mysore and the neighbouring tracts there is a great preponderance of the Ostariophysi. Of the 121 species listed above, as many as 102 belong to this order (81 to the Suborder Cyprinoidea and 21 to the Siluroidea). Out of the 81 Cyprinoid fishes, there are 15 species of loaches, 2 belonging to the family Homalopteridae and 13 to the Cobitidae, and 66 true Carp or Cyprinidae. Of the remaining 19 species, 1 belongs to the Apodes (Anguillidae), 1 to the Synentognathi (Xenentodontidae), 3 to the Microcyprini (Cyprinodontidae), 10 to the Percomorphi (Ambassidae 2, Cichlidae 1, Gobiidae 1, Polycanthidae 1 and Ophicephalidae 5) and 2 to the Opisthomi. The Percomorphi are rather poorly represented in the above list and it is surprising that even some of the widely distributed species do not appear to have been recorded from this region. It seems certain that when a detailed fish survey of the State is completed many more species will be added to its fauna.

## ZOOGEOGRAPHICAL REMARKS ON THE FISH-FAUNA OF MYSORE.

As regards physical features, the Mysore State has been broadly divided into two areas, the Maidan and the Malnad. The former comprises the eastern part of the State; it is a plain, cultivated country with a gentle slope towards the east. According to Blanford<sup>1</sup>, the

<sup>1</sup> Blanford, W. T. *Phil. Trans. Roy. Soc. London* (B), CXIV, p. 346 (1901).

Maidan area of Mysore is included in the Carnatic or Madras zoogeographical tract which is defined as follows :—

“ The Peninsula south of the Kistna or of 16°N. lat.,<sup>1</sup> and east of the Western Ghats, comprising the Carnatic and Mysore. The plains of the Carnatic are much like those of the Deccan and are for the most part cleared, but there are scattered hill groups, generally covered with forest and with a much higher rainfall than the plains. The average temperature is slightly higher than that of the Deccan, but more equable, the average annual range of the thermometer being considerably smaller. The average rainfall is about 35 inches.”

Blanford recorded the occurrence of the following genera of fresh-water fishes from the Carnatic Tract :

<i>Symbranchus.</i>	<i>Lepidocephalichthys</i> (= <i>Lepidocephalus</i> ).
<i>Anguilla.</i>	<i>Jerdonia.</i>
<i>Clarias.</i>	<i>Nemachilus.</i>
<i>Saccobranchus</i> (= <i>Heteropneustes</i> ).	<i>Discognathus</i> (= <i>Garra</i> ).
<i>Wallago</i> (= <i>Wallagonia</i> ).	<i>Labeo.</i>
<i>Callichrons.</i>	<i>Cirrhin.</i>
<i>Ailia.</i>	<i>Amblypharyngodon.</i>
<i>Pseudotropius.</i>	<i>Barbus.</i>
<i>Pangasius.</i>	<i>Nuria</i> (= <i>Esomus</i> ).
<i>Silundia</i> (= <i>Silonia</i> ).	<i>Rasbora.</i>
<i>Macrones</i> (= <i>Mystus</i> ).	<i>Rohlee.</i>
<i>Rita.</i>	<i>Barilius.</i>
<i>Bagarius.</i>	<i>Danio.</i>
<i>Glyptosternum</i> (= <i>Glyptothorax</i> ).	<i>Perilampus</i> (= <i>Laubuca</i> ).
<i>Chela.</i>	<i>Mastacembelus.</i>
<i>Notopterus.</i>	<i>Ophicephalus.</i>
<i>Ambassis.</i>	<i>Anabas.</i>
<i>Gobius.</i>	<i>Polyacanthus.</i>
	<i>Etioplus.</i>

Of the genera enumerated above, *Jerdonia* is endemic in this tract, *Polyacanthus* and *Etioplus* are found in Peninsular India and Ceylon, while the remaining 34 genera are common to the Indo-Gangetic plain, Indian Peninsula and Burma.

The Malnad is the western part of the State ; it is composed of hilly tracts with peaks ranging from 4,000 to 6,000 feet above sea level. Blanford included this area in his Malabar Tract—“ Western Ghats and the western coastlands of the Peninsula from the Tapti River to Cape Comorin.” The Nilgiris, the Wynad and Coorg are definitely included in the Malabar tract. According to Blanford's lists, the following additional genera are found in the Malabar tract of the Mysore State :

<i>Silurus</i>	<i>Scaphiodon</i> (in part= <i>Osteochilus</i> )
<i>Homaloptera</i> (in part= <i>Bhavana</i> )	<i>Sicydium</i> (in part= <i>Sicyopterus</i> ).

<sup>1</sup> In a foot-note, Blanford observed that “ This boundary should perhaps be placed further south. Originally these tracts were arranged to mark the distribution of the Cyclophoridae. After going through all the evidence, I am inclined to think that a more important line might be drawn about 12°N. lat.”.



These genera have a restricted and discontinuous distribution in India. According to Blanford's tables, *Silurus* is found in the Malabar tract, the Eastern Himalayan tract, the Assam tract, and the Tenasserim tract. Formerly two or three species of *Silurus* were recognised from within the limits of India, but, as indicated above, Bhimachar and Subba Rau have shown that it is the same species that is found from Cochin-China to the Eastern Himalayas and also in the Western Ghats. Similarly, the Homalopteridae, of which *Bhuvania* is a highly specialised member, are found throughout south-eastern Asia up to the Eastern Himalayas and the hills of Assam, and also in the Western Ghats. These two genera, recorded by Bhimachar and Subba Rau from the Kadur District, represent the so-called Malayan element in the fauna of Mysore. I<sup>1</sup> have recently shown that Day's three species of *Scaphiodon* from Peninsular India are referable to *Osteochilus*, a genus widely distributed in south-eastern Asia. In the same place it has been shown that *Cyprinus nukta* Sykes belongs to the Malayan genus *Schismatorhynchus* which was hitherto known only from Sumatra and Borneo. *Sicydium* is recorded from the Malabar and the Northern Ceylon tracts and from the Malay Peninsula. It is a Gobioid genus, which seems to have invaded fresh waters from the sea and for this reason its distribution is not of much significance. Law and the present writer<sup>2</sup> have recently discussed the significance of the Malayan element in the fauna of Peninsular India and the route of dispersal of the above-noted forms from their original home in south-eastern Asia to the Western Ghats.

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<sup>1</sup> Hora, S. L. *Rec. Ind. Mus.* XLIII, pp. 1-14 (1941).

<sup>2</sup> Hora, S. L. and Law, N. C. *Rec. Ind. Mus.* XLIII, pp. 233-256 (1941).

# HELMINTH PARASITES OF CERTAIN RATS IN INDIA.

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and

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The rat, more than any other wild animal, has adapted itself to man's habitations and is found in them all, from the most modern mansion in highly civilised countries to the most lowly hut of primitive races, so that all over the world this rodent is found living in much closer association with man than many of his so-called domestic animals. It has long been recognised that on account of its ubiquity, the rat is important as a transmitter or reservoir of certain diseases of human beings. Its greatest importance is probably with regard to bubonic plague, but as a host of numerous helminths it deserves attention also, and many censuses of its worm parasites has been taken in various parts of the world.

As far as we are aware, no systematic examination of rats has been made in India from the helminthological standpoint. We give below the results of our examination of 100 rats brought for routine plague examination to the Public Health Department of Bengal, to whom we are indebted for the material. This material has been recently amplified by the receipt of a large collection of worms from the Central Research Institute, Kasauli, which contained collections from 28 rats, nearly all collected in the Ambala District, Punjab.

The species of rat we examined in Calcutta was *Mus decumanus* Pallas, but the identification of the rats providing the Kasauli collection is not known nor the number of rats that were dissected to provide the 28 collections of worms. Therefore, the latter are shown below separately.

The following parasites were obtained from 100 specimens of *Mus decumanus* Pallas, from Calcutta, the number besides each species representing the number of host-specimens infected with it; 28 were uninfected. Multiple infections were common, but they have not been analysed and shown separately.

## NEMATODA.

<i>Heterakis spumosa</i>	..	..	..	..	..	..	41
<i>Syphacia baylisi</i> , sp. nov.	..	..	..	..	..	..	17
<i>Mastophorus muris</i>	..	..	..	..	..	..	3
<i>Subulura andersoni</i>	..	..	..	..	..	..	1
<i>Capillaria prashadi</i> , sp. nov.	..	..	..	..	..	..	1
<i>Oxyuridae</i>	..	..	..	..	..	..	1

## CESTODA.

<i>Hymenolepis diminuta</i>	..	..	..	..	..	..	14
<i>Hymenolepis nana</i>	..	..	..	..	..	..	7
<i>Railiellina celebensis</i>	..	..	..	..	..	..	6
<i>Oochoristica symmetrica</i>	..	..	..	..	..	..	2
<i>Cysticercus fasciolaris</i>	..	..	..	..	..	..	11

## ACANTHOCEPHALA.

<i>Moniliformis moniliformis</i> .. .. .	20
No parasites .. .. .	28

The Kasauli collection contained the following parasites :

## NEMATODA.

<i>Mastophorus muris</i> .. .. .	11
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## CESTODA.

<i>Hymenolepis diminuta</i> .. .. .	9
<i>Oochoristica symmetrica</i> .. .. .	1
<i>Cysticercus fasciolaris</i> .. .. .	7

## NEMATODA.

***Syphacia baylisi*, sp. nov.**

Baylis (1936) recorded some female worms belonging to this genus which had been obtained from *Rattus rattus* at Lyallpur, Punjab. He expressed the opinion that these worms probably represented a new species, principally because the eggs measure  $0.07 \times 0.03$  mm. compared with eggs of the size of  $0.12-0.13 \times 0.036-0.04$  mm. found in a species of *Syphacia* obtained from a *Mus musculus* Linn. in Ceylon. This worm was identified as *S. obvelata* or *S. stroma*, but there is some doubt at present whether these two species are identical or different.

The worms in our collection obtained from 17 rats were all females ; 10 of these, which were measured, agreed with the measurements of Baylis' Lyallpur material. The sizes of eggs in our specimens were  $0.078-0.02 \times 0.029-0.034$  mm. We consider that these results confirm Baylis' opinion that this is a distinct species with shorter eggs than those of *S. obvelata*. Even in the absence of males, we name this new species as *S. baylisi*.

***Subulura andersoni* (Cobbold, 1876) Railliet & Henry, 1914.**

This species was fully redescribed by Thwaite (1927) and there seems little doubt that our worms are the same species because nearly all the measurements fall within the limits given by him. The maximum length of both sexes is 0.5 to 1 mm. more than Thwaite's, a quite insignificant difference. The only other difference is in the position of the vulva which is 6.8 mm. from the anterior end in Thwaite's description, and is 9.2-9.8 mm. in our material. This is not, in our opinion, sufficient to justify making a new species, and its significance is lessened by the fact that our worms were longer than Thwaite's.

Mirza (1936) described a new species, *S. hindi*, basing his differentiation on Cobbold's original description of *S. andersoni*. He was evidently unaware that Thwaite (1927) had redescribed *S. andersoni* in detail. If Mirza's and Thwaite's drawings and descriptions are compared the following points emerge.

Mirza bases the differentiation of his species from *S. andersoni* on the following three points : " Number and disposition of caudal papillae in the male, the length of the spicules, and the position of the vulva in the female ". Regarding the caudal papillae, the disposition depicted

in the drawings of both authors is the same, but Mirza shows a third pair of papillae in the most posterior group. These papillae are very small and in our material it was in some cases hard to determine whether the third pair was present or not. Therefore, this point is not considered to be of specific value. Variation in this group of papillae is well known and accepted fact in several allied genera. Mirza says that the spicules are equal and are 9.1 mm. in length. Thwaite says they are equal or subequal and measure 0.85-1 mm. in length, and we found them to be 0.9-1.06 mm., so that this character is of no value. The vulva is given as 5.69 mm. from the anterior end by Mirza, 6.5-8 mm. by Thwaite and we found it to be 9.2-9.8 mm. in slightly larger worms, and as this is the sole difference that remains we do not consider it to be of any specific value. In view of these facts we consider that *S. hindi* Mirza, 1936, is a synonym of *S. andersoni* Cobbold, 1876.

### **Mastophorus muris** (Diesing, 1853) Chitwood, 1938.

Chitwood (1938) divided the worms contained in the genus *Protopirura* Seurat, 1914, into two groups leaving some of them in *Protopirura*, and placing the others in *Mastophorus* Diesing 1853; and *muris* becomes the type of *Mastophorus* for the following reasons. Seurat, when he created the genus *Protopirura*, named *P. numidica* Seurat, 1914 as the type; he next transferred *Lumbricus muris* Gmelin, 1790 to this genus and, a little later, said that it was identical with *Mastophorus echiurus* Diesing, 1853. Stiles and Hassall had made *M. echiurus* the type of *Mastophorus* by "subsequent designation" in 1905. Therefore, according to the rules, the genus *Protopirura* becomes invalid. But since the worms in this group, headed by the original type of the genus, namely *P. numidica*, are clearly defined, Chitwood recommends retaining this generic name.

The correct name and synonymy of the species under discussion is therefore:—

*Mastophorus muris* (Diesing, 1853) Chitwood, 1938.

Syn. *Lumbricus muris* Gmelin, 1790.

*Protopirura muris* Seurat, 1915.

*Mastophorus echiurus* Diesing, 1853.

Syn. *Protopirura muris* Seurat, 1916.

A further point is that Chitwood distinguished two varieties of *M. muris*, viz., *M. muris muris* with large teeth and *M. muris ascaroides*<sup>1</sup> with small teeth. All our specimens belong to the large-toothed variety. He also expressed the opinion that four of the other species that he put in this genus, viz., *columbiana*, *gracilis*, *labiodentata* and *oligodonta* are identical with *M. muris muris* and that another species, *marsupialis*, is also probably the same.

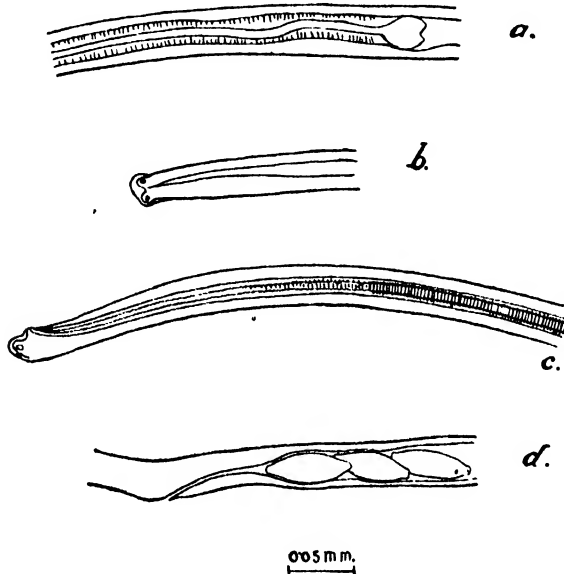
The species he leaves in *Protopirura* are: *numidica*, *muricola*, *bonnei* and *suslica*.

<sup>1</sup> Hall (1916) named the species as *Protopirura ascaroidea* and not *ascaroides*. Therefore, the varietal name used by Chitwood should be *ascaroidea*.

**Capillaria prashadi, sp. nov.**

This species was found in only one rat, *Mus decumanus*.

*Male*.—Only a single male was found and the anterior end was missing, so that the full length cannot be given. The length of the fragment was 7 mm., and if this is compared with the lengths of the whole females it is clear that the greater part of the specimen was recovered. The maximum diameter is 0.49 mm. The worm ends in a rounded cuticular expansion which is supported by a pair of thick ray-like prolongations of the body. These rays end in small papillae directed dorsally. The anus is subterminal (figs. b, c). The



*Capillaria prashadi*, sp. nov.

a. Proximal end of spicule (lateral view); b. Posterior end of male (dorsal view); c. Posterior end of male (lateral view); d. Vulvar opening of female (lateral view).

spicule is lightly chitinized and at the proximal end it has a bulbous dilation which is  $0.023 \times 0.022$  mm. (fig. a). The total length of the spicule is 0.95 mm.; it is 0.008 mm. thick just behind the bulb, and tapers slightly towards the tip, being 0.006 mm. in diameter just before it narrows to end in a fine straight point; the spicule sheath is muscular with transverse striations, and it has spiral markings on its inner surface (fig. c).

*Female*.—The six females, which were intact, measured 10.2-13 mm. in length and 0.61-0.67 mm. in maximum diameter. The oesophagus is 4.2-5.3 mm. in length, and the vulva which is a simple opening without lips, is 0.1-0.2 mm. behind the posterior end of the oesophagus (fig. d). The eggs are 0.058-0.064 mm. in length, including the terminal plugs, and 0.024-0.029 mm. in maximum diameter; the shells show radial striations, but no surface pattern could be made out.

A careful comparison with the most nearly similar species of *Capillaria* of mammals listed by Travassos (1936) demonstrates that this is

a distinct species. For example, *C. muris-sylvatici* differs with regard to the posterior end of the male, the shape of the spicule and the vulva in the female. It resembles *C. felis-catæ* and *C. auritæ* in the male caudal extremity, but the spicules, spicule-sheaths and eggs are of different shapes and dimensions. In *C. linsi* the caudal end of the male is also similar and the proximal end of the spicule is dilated, but in this case it is definitely funnel-shaped and not globular as in our species, and the length of the spicule is also different. Since the other known species differ greatly from *prashadi*, a detailed comparison is not necessary.

The name *Capillaria prashadi*, sp. nov. is proposed for this worm in recognition of the kind assistance received over many years from Dr. Bains Prashad, Director, Zoological Survey of India, in the identification of the hosts of our parasitic worms and in many other ways.

#### Fam. OXYURIDÆ.

Some Oxyurid worms were also found, but as only females were available, and nothing sufficiently characteristic was found these could not be identified.

#### CESTODA.

##### ***Railletina celebensis* (Janicki, 1902).**

All the specimens obtained by us agreed with *R. celebensis* or *R. celebensis paucicapsulata*, except that there were no spines, and in two worms the genital pores were not unilateral throughout the strobila.

The absence of spines is of no importance, as it is generally accepted that they are lost during fixation.

The alternation of the genital pores is a more important character, but in the present instance we are inclined to regard it as a variation of no specific value, because the alternation only occurred once or twice in the whole chain and there were 20 to 30 segments with pores all on one side followed by a similar number with the pores on the opposite side. Such a condition is very different from the usually accepted definition of alternating pores which means two or three pores on the side followed by two or three on the other, throughout the length of the worm.

It was also noted in two of our worms that the number of egg capsules varied from 95 to over 200 in different segments of the same worm. Meggitt and Subramanian (1927) created the variety *R. celebensis paucicapsulata* on the fact that *R. celebensis* has 180 to 200 egg-capsules to a segment, whereas their worms had 100 to 120 egg-capsules. Our discovery of a much wider variation of capsules in a single chain indicate that this distinction is not valid and that consequently the name *R. celebensis paucicapsulata* should be dropped.

##### ***Hymenolepis nana* (v. Siebold, 1852) Blanchard, 1891.**

In considering this species we have followed the now generally accepted fact that *H. fraterna* and *H. longior* are identical with *H. nana*

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## ON STRIGEIDA (TREMATODA) FROM INDIA<sup>1</sup>.

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A fairly large number of "Holostomes" have been recorded from this country, mainly as a result of the researches of Verma (1936) and Vidyarthi (1937-38). Unfortunately in a large majority of cases the descriptions given are far from satisfactory and the taxonomic positions of the parasites concerned erroneously determined. This is probably due to the difficult nature of the group and to the fact that the relevant literature is scattered and is inaccessible to the average Indian worker. Recently (1938), however, Dubois has brought out a very comprehensive monograph on this group of parasites. In the present monograph it is intended to offer criticism in regard to the shortcomings of the descriptions and the wrong interpretations of structure. Wherever possible an attempt has been made to assign the proper systematic position to the species which, in the opinion of the writer or other workers, were wrongly classified. Some time ago the writer endeavoured to obtain specimens from other workers but met with little success. The object of the present communication is to stimulate workers in this country to re-examine their old specimens with a view to providing the missing links in their description and to interpreting correctly the different structures. This will facilitate the work of the taxonomist and will, it is hoped, largely remove the existing confusion in this complicated group of parasites. It may be remarked here that *Cleistogamia holothuriana* Faust, 1924 has been shown to be a Rhadocoele Turbellarian of the family Umagillidae by Baer (1938).

1. *Apharyngostrigea egretti*. Verma (1936a) gave a very brief account of this parasite from the intestine of a Cattle Egret shot near Patna. No figure is given.

2. *A. ardeolina*. Vidyarthi (1937 d) described this species from the intestine of the Eastern Grey Heron shot near Pholpore, Allahabad.

3. *A. indiana*.—Vidyarthi (1937 d) described this species from the intestine of *Egretta alba* at Allahabad. The measurements of the eggs appear to have been ten times exaggerated.

4. *A. simplex*.—This has been recorded from the intestine of a Night Heron shot at Allahabad. It was originally described as *Holostomum simplex* by S. J. Johnston (1904) from a heron in Australia and was later assigned to the genus *Strigea* by Mathias (1925). Szidat placed it under *Apharyngostrigea* in 1929. Only a very meagre account of this parasite is available. In the original description, the pharynx is stated to be much smaller than the suckers but there is no indication of this organ in the figures. It is noteworthy that the genus is characterised by the absence of a pharynx.

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<sup>1</sup> Paper read before the Zoology Section of the 29th session of the Indian Science Congress, Baroda, 1942.



5. *Ophiosoma macrocephalum*.—Verma (1936 a) obtained this species from the intestine of a Hawk Cuckoo in Allahabad and gave a very brief description.

6. *O. microcephalum*.—This species was originally described by Szidat (1928) from the intestine of *Buteo magnirostris* and *Circus cyaneus* in Brazil. Verma (1936 a) claims to have obtained this species from the intestine of herons in Allahabad. He has published neither a description nor a figure of the parasite.

7. *Ridgeworthia rami*.—This species, assigned to a new genus and obtained from the intestine of a Night Heron in Allahabad, was described by Verma (1936 a). The genus like *Pulvinifer* Yamaguti possesses muscular patches at the lateral corners of the fore-body. The hold-fast organ is a peculiar muscular ridge bent upon itself.

8. *Strigea annandalei*.—Faust (1927) described this metacercarial from encysted in the subcutaneous tissue and muscles of the small loach, *Nemachilus rupicola*, obtained in the hill streams in Kashmir. He assigned this form to the genus *Strigea* though its position in this genus would appear to be improbable on account of the presence of a long neck region; moreover the hold-fast organ is stated to be absent in the metacercaria. Presumably the structure is labelled in figure 7 pl. XVIII as the hold-fast organ in error. In his description of the parasite, he refers to a canal which he designates "cirrus sac". In reality this tubular portion of the male genital duct should be called ductus ejaculatorius, since the whole of the superfamily Strigeides is characterised by the absence of a cirrus sac. Faust remarks: "This latter organ (Vesicula seminalis) opens into a canal (the cirrus sac), which empties along with the uterus into the genital atrium". This statement gives the impression that the ductus ejaculatorius (cirrus sac of Faust) and the uterus open into the genital atrium separately. As a matter of fact, the ductus ejaculatorius unites with the terminal portion of the uterus to form an hermaphroditic duct which opens into the genital atrium. This is evidenced in Faust's figure but his description is incorrect.

9. *S. elongata* var. *indica*.—This variety was obtained by Verma (1936 a) from the intestine of the Black-headed Oriole in Calcutta. The variety differs from the species *Strigea elongata* Yamaguti, 1935 in that the host is different, as are also the dimensions of the body, while the anterior testis is larger. It would appear that the incorrect dimensions of the eggs are the fault of the printer.

10. *S. falconis* Szidat, 1928.—Gogate (1940b) gave a very meagre description of the parasite. He does not make any mention of the adhesive gland and the details of the genitalia are insufficient.

11. *S. falconis* var. *eaglesa*.—Verma (1936 a) has recorded this variety from the intestine of the Indian Fishing Eagle in Bihar. The variety is stated to differ from the species *Strigea falconis* Szidat, 1928, in the dimensions of the body and of the internal organs.

12. *S. globocephala*.—Verma (1936 a) described this species from the intestine of the Crested Serpent Eagle in Bihar. The species is stated to have a close affinity with *S. elongata* and *S. falconis* but to differ from both of them in the more forward position of the ovary and testes.

13. *S. orientalis*.—Vidyarthi (1937 *d*) described this species from the small intestine of a King Vulture shot in the suburbs of Allahabad.

14. *S. nephronis*.—Vidyarthi (1937 *d*) described this species from the intestine of the Scavenger Vulture.

15. *S. streptocorpus*.—Verma (1936 *a*) described this species from the intestine of the Fishing Eagle in Bengal. The species was originally assigned to the genus *Cotylurus* but, as the vitellaria extend into the fore-body, Dubois (1938) transferred it to *Strigea*. The writer is in entire agreement with this. Verma gives a very brief account of this parasite.

16. *Apatemon sarcogyponis*.—Vidyarthi (1937 *b*) described this species from the intestine of *Sarcogyps calvus* in Allahabad and assigned it to the genus *Pseudostrigea* Yamaguti, 1933. In order to accommodate his species in the genus, he modified the definition of the genus *Pseudostrigea*. Dubois (1938, p. 491) remarks that the emended diagnosis of *Pseudostrigea* does not differ in any way from that of *Apatemon* Szidat, 1928. The degree of development in the musculature of the bursa copulatrix is not considered by him to be a character of generic importance. Vidyarthi describes the presence of "two prominent sucker pockets, one on each side of the oral sucker". Yamaguti (1933), in describing the genotype, remarks; "At the anterior end of the body there is a prominent sucker and a broad notch on either side of it. Immediately behind these notches there are conspicuous lateral depressions similar in structure as in all the members of the subfamily Strigeini". It would appear from the above remarks that Dubois is definitely in favour of assigning this species to *Apatemon* and the writer is in complete agreement with this view.

17. *A. casarcus*.—Vidyarthi (1937 *b*) described this species from the intestine of *Casarca ferrunginea* in Allahabad.

18. *A. indicus*.—Vidyarthi (1937 *b*) described this species from the intestine of *Casarca ferrunginea* in Allahabad.

19. *A. pandubi*.—Recently Pande (1939) described this species from the intestine of the Indian Darter or Snake-bird from Allahabad.

20. *Cotylurus orientalis*.—Vidyarthi (1937 *b*) described this species from the intestine of the common Teal in Allahabad. He claims to have seen a receptaculum seminis in this species, although the whole of Strigeida is characterised by its absence. He also describes a genital cone. The genus *Cotylurus* does not possess this structure. It would, therefore, appear that Vidyarthi failed to interpret correctly the various parts of the genitalia of this parasite. In this genus the protrusion of the genital pore is caused by the protraction of the anterior and dorsal wall of the bursa. This was probably mistaken by Vidyarthi for the genital cone. In regard to the receptaculum seminis, this structure does not exist at all.

21. *Diplostomum ketupanensis*.—Vidyarthi (1937 *c*) described this species from the intestine of the Northern Brown Fishing Owl in Lucknow. He mentions a small genital cone but presumably this is a mistake; as the genus is characterised by the absence of this structure.

22. *D. buteii*.—Vidyarthi (1937 *c*) described this species from the intestine of *Buteo rufinus rufinus* in Lucknow.

23. *D. thaparia*.—Lal (1939) described this species from the intestine of a King Vulture in Lucknow and assigned it to his new genus *Neolaria*. He tried to separate this genus from *Alaria* and *Proalaria* thus indicating that it belongs to Alariinae. The location of the vitellaria, however, is against this decision. The fact that in this species the vitellaria are present in both segments of the body and are well distributed, places it in the subfamily Diplostomini. In this group it approaches most nearly to the genus *Diplostomum*. Amongst other peculiarities of the species, Lal emphasises the instinct division of the fore- and the hind-body, the trough-shaped hold-fast organ and the peculiarly dumbbell-shaped tests. In many species of *Diplostomum* the body is somewhat indistinctly divided into two regions. In many the tests are bi-lobed. The hold-fast organ in some species has a tendency to recurve anteriorly or posteriorly. Probably this recurving was much pronounced in Lal's species. The bursa is simple in all the members of the genus *Diplostomum*. From all these considerations, it must unmistakably belong to the genus *Diplostomum*.

24-27.—Verma (1936 a) mentions four forms obtained respectively from a Duck and a Sea Eagle in Calcutta and an Osprey and a Vulture in Allahabad. All these, according to Verma, are referable to *Diplostomum* (syn. *Proalaria*). He gives no description of these parasites and withholds his final decision about them.

28. "*Proalaria alcedensis*".—This parasite has been recorded by Patwardhan (1935) from the intestine of the King Fisher in Nagpur and by Verma (1936 a) from the intestine of the Pied King Fisher in Allahabad. In the first instance it should be noted that *Proalaria* is a synonym of *Diplostomum*. This species cannot, however, be included in this genus since the vitelline follicles are confined to the posterior segment of the body. Dubois (1938) doubts the presence of pseudo-suckers in the species. In the figure they are not represented as definite organs and it is possible that their supposed presence may have been more apparent than real. The terminal parts of the genital ducts are not described.

29. *Neodiplostomum kashmirianum*.—Faust (1927) described an encysted form from the skin nodules of *Schizothorax curvifrons*, *S. niger* and *Crossochilus latea* in Kashmir. As in the previous case, namely, that of *Strigea annandalei*, the bursa copulatrix is mistaken for the "cirrus-pouch".

30. *N. cochleare* var. *calaophilum* Dubois, 1938.—Originally Verma (1936 a) described briefly specimens from the Horn-bill in Calcutta as the species *N. cochleare* but Dubois (1938) created a new variety for it as it appears in a different host and as the eggs are much larger.

31. *N. cuckooai*.—Verma (1936 a) originally described this species from a cuckoo in Allahabad and assigned it to his newly created genus *Procrassiphiala* but as the host is of a different order (not Charadrii) and as the posterior portion of the body is smaller than the anterior Dubois (1938) places it in the genus *Neodiplostomum*. He considers that the species approaches *N. ellipticum* (Brandes, 1888) and this would appear to be very probable. Verma gives an extremely brief account of this parasite.

32. *N. dilacaecum*.—Lal (1939) describes this species from the intestine of *Athene brama* in Lucknow. Unfortunately he does not describe the bursa copulatrix.

33. "*N. gavialis*".—Narain (1930) originally described this species from the intestine of *Gavialis gangeticus* in Allahabad. Vidyarthi (1937 a) assigned it to the genus *Crocodilicola*. Dubois (1938), however, does not agree with Vidyarthi, as in this species the genital system, with the various genital ducts, is not described in sufficient detail to make it possible to assign it to any genus of Strigeida. He, therefore, prefers to retain the original nomenclature placed in inverted commas.

34. *N. globiferum*.—Verma (1936 a) described this species from the intestine of a cuckoo in Allahabad. The terminal portions of the genital ducts and the bursa copulatrix are not properly described.

35. *N. gumbudia*.—Gogate (1940 b) described very briefly an immature specimen of this species from the intestine of a common Kite in Pilibhit.

36. *N. laruci*.—Vidyarthi (1938 a) described this species from the intestine of *Sarcogyps calvus* in Allahabad. In this species, also, the bursa copulatrix and the genital ducts are inadequately described.

37. *N. mehranum*.—Vidyarthi (1938 a) described this species from the intestine of *Haliaetus leucoryphus* in Allahabad. The bursa copulatrix and the terminal portions of the genital ducts are not described.

38. *N. mehrii*.—This species was originally described as *Neodiplostomoides mehrii* by Vidyarthi (1938 a) from the intestine of a Bonell's Eagle in Allahabad. Dubois (1938) remarks that the genus *Neodiplostomoides* differs from *Neodiplostomum* by the (?) presence of a genital bulb and the form of the testes. He doubts whether a genital bulb really did exist in the specimen described by Vidyarthi: the posterior extremity of the body was very much deformed and, moreover, the form of the testes is considered by him to be of secondary importance. The species is, therefore, here assigned to the well-established genus *Neodiplostomum*.

39. *N. orientalis*.—Vidyarthi (1938 b) originally described this species from the intestine of *Buteo rufinus rufinus* in Allahabad and assigned it to the genus *Bolbophorus*. Vidyarthi describes the presence of pseudo-suckers in this species but the correctness of this is very much open to question. Dubois (1938) remarks that, taking into account the host, the pointed cephalic extremity and the structure of the bursa copulatrix it is doubtful whether this species can really be assigned to the genus *Bolbophorus*. It appears to be a member of the genus *Neodiplostomum*.

40. *Neodiplostomum* sp.—This form, insufficiently described, was reported by Lal (1939) from the intestine of the Blue Jay in Lucknow.

41. *N. tytense*.—This form was originally described by Patwardhan (1935) from the intestine of *Tyto alba stertens* in Nagpur. Verma (1936 a) recorded it from the Osprey and the common vulture in Allahabad. The bursa copulatrix and the terminal portions of the genital ducts are not described by Patwardhan. Verma obtained from a kestrel in Allahabad somewhat similar forms which were shorter than *N. tytense*. The forms from the kestrel were 1.85-2.05 mm. long and in them the fore- and the hind-body were in the proportion of 1: 1.1, and the vitellaria

extended more anteriorly than in *N. tytense*. Verma reserves his final opinion on these, remarking that they may be a different species.

42. *N. bagulum*.—Lal (1939) described this species from the intestine of the Eastern Grey Heron in Lucknow. He assigned this species to the genus *Pharyngostomum* of the subfamily Alariinae. The members of this subfamily are parasites of mammals and very rarely of birds; moreover, in this subfamily the vitelline follicles are confined to the anterior segment of the body. This species, having an avian host and the vitelline follicles distributed in both segments of the body, can be assigned to the subfamily Diplostominae and the subfamily Diplostomini Dubois, 1931. In this subfamily it can easily be assigned to the genus *Neodiplostomum* on account of the absence of pseudo-suckers, the body being distinctly bisegmented, the bursa copulatrix being very small and non-evaginate, the oral sucker being elliptical and the anterior segment of the body being longer than the posterior. The only thing puzzling about this parasite is that the anterior testis is larger than the posterior and the former is bilobed while the latter is more or less pear-shaped. This is rather an exceptional feature, the reverse being the rule amongst this group of parasites. As a matter of fact, no known member of *Neodiplostomum* possesses the testicular character described by Lal. It is, therefore, probable that Lal has incorrectly interpreted the testicular structures. The two obliquely situated large lobes appear to be parts of the posterior testis and the asymmetrical smaller lobe on the left side appears to be the anterior testis. With this rectification in the interpretation of the testicular structures, the species described by Lal can be assigned to the genus *Neodiplostomum*.

43. *Allodiplostomum hindustani*.—Verma (1936 a) described this species from the intestines of the Indian Red-wattled Lapwing in Allahabad. He has given a short description and the measurements of the pharynx, the anterior testis and the ovary appear to be erroneous.

44. *Procrassiphiala triticum*.—Verma (1936 a) described this species from the intestine of the Red-wattled Lapwing in Allahabad and assigned it to his newly created genus *Procrassiphila*. He defined this genus very briefly and, as remarked by Dubois (1938), there do not exist outstanding anatomical differences between this genus and *Neodiplostomum* Railliet, 1919. Dubois has, however, accepted this genus on the grounds that the fore-body is broader than the hind-body and that the latter is much longer than the former.

45. *P. halcyonae*.—Gogate (1940 a) described this species from the intestine of *Halcyon smyrnensis* in Rangoon.

46. *Glossodiplostomoides* gen. nov.—Vidyarthi (1938 b) described *Glossodiplostomum hieraetii* and *G. buteoides* from the intestine of *Hieraetus fasciatus* and *Buteo rufinus* respectively in Allahabad. Dubois (1938) considers that the latter species is a synonym of the former and he appears justified in holding this opinion. Except for minor differences both species seem to be identical. The question now arises whether Vidyarthi is justified in assigning these species to *Glossodiplostomum* as Dubois suspects. This genus is up to the present moment represented by the single species *G. glossoides* (Dubois, 1928) Dubois, 1932. A comparison of this species with *G. hieraetii* (syn. *G. buteoides*) indicates that the latter

species differs from the former in many important respects, viz., (1) a marked difference between the fore- and the hind-body, the hind-body being at least twice as long as the fore-body, (2) a larger hold-fast organ and (3) the occupation of more body space by the genital organs. These points of difference being very significant, it is proposed to create a new genus for its reception for which the name *Glossodiplostomoides* is suggested. The new genus is defined as follows :—

**Diplostomini:** Body somewhat indistinctly bisegmented: constriction being absent. Fore- and hind-body distinct. Anterior end bearing oral sucker conical. Maximum breadth in the region of the hold-fast organ. Cuticle smooth. Fore-body spoon-shaped. Hind-body cylindrical, more than twice the length of fore-body. Pseudo-suckers present. Hold-fast organ spherical, one-eighth to one-fourth of the total body length. Genital pore subterminal. Genital organs occupying half the total length of the body. Testes transversely oval, tandem or slightly oblique. Ovary anterior to testes. Vitellaria arranged in two lateral bands. Eggs few, operculate.

*Type species.*—*G. heiraetii* (Vidyardhi, 1938) Bhalerao, 1942.

47. *Posthodiplostomum botauri*.—Vidyardhi (1938 a) described this species from the intestine of *Botaurus stellaris* in Allahabad. He does not make any mention of the hermaphroditic duct. It is not stated whether the bursa copulatrix is eversible, this being one of the important generic characters.

48. *P. grayii*.—Verma (1936a) described this species from the intestine of the Pond Heron assigning it to the genus *Proalaria*, which is a synonym of *Diplostomum*. Dubois (1938), however, assigns it to *Posthodiplostomum*, mainly on account of the eversible nature of the bursa, the terminal genital pore, the limited anterior and posterior extent of the vitelline follicles, the presence of the acetabulum in the posterior half of the fore-body, the form and situation of the genital glands and the adaptation to Ardeidae. He doubts the presence of “an accessory pit, with hair-like cilia projecting outwards, on margin of fore-body a short distance behind oral sucker”. This is evidently a pseudo-sucker but the genus *Posthodiplostomum* is devoid of this structure. Should this prove to be correct, the forms described by Verma will have to be placed in a new genus.

49. *Uvulifer ceryliformis*.—Vidyardhi (1938 a) described this species from the intestine of *Ceryle radis leucomalanara* in Allahabad and assigned it to the genus *Crassiphiala*. It does not, however, fit exactly into this genus since its hold-fast organ is much smaller and does not extend anteriorly as far as the pharynx. It has closer affinity with the genus *Uvulifer* Yamaguti, 1934 from which it differs only in the absence of the ventral sucker. In this respect it agrees with *Crassiphiala*, but the nature of the hold-fast organ has more taxonomic importance than the absence or presence of the acetabulum. For this reason it is assigned to the genus *Uvulifer*.

50. *U. stunkardi*.—Pande (1938) described this species from the intestine of *Halcyon smyrensis fusca* in Allahabad and assigned it to the genus *Crassiphiala*. This species does not satisfy all the requirements

of the genus *Crassiphiala*: the acetabulum being much smaller than normal. It, however, agrees in all respects with the genus *Uvulifer*.

51. *Pseudodiplostomum cochlearis*.—Verma (1936 a) gave a brief account of this species from the intestine of the King Fisher in Allahabad. As remarked by Dubois (1938), this species having a smaller ventral sucker has affinity with the genus *Uvulifer*. As against this it is supposed to have no genital bulb. This character precludes one from assigning it to *Uvulifer*. This structure being more important than the comparative sizes of the two suckers, the writer agrees with Dubois in keeping it tentatively in the genus *Pseudodiplostomum*.

52. *P. fraterni*.—Verma (1936 a) described very briefly this species from the intestine of *Ceryle radis* in Allahabad.

53. *Alaria robusta*.—Verma (1936 a) described this species from the intestine of the King Vulture in Allahabad. This is the only species of the genus recorded from a bird. The infection is very probably accidental. Normally *Alaria* is found in Mammalian hosts.

54. *A. alata*.—Maplestone and Bhaduri (1940) recorded this species from a dog in Calcutta. The joint authors do not mention the organ of infection but it has been known to occur in the stomach, duodenum, small and large intestines, rectum and hepatic canals of the host.

55. *Travassosstomum tropidonotus*.—This species, obtained from the intestine of *Natrix piscator*, was described by Vidyarthi (1937 a) under the name *Proalarioides tropidonotus*. Simultaneously with this a paper by the present writer giving an account of the same parasite was in the press at Rio de Janeiro in connection with the Jubilee Volume published in 1938 in honour of Prof. Travassos. Since the paper of Vidyarthi appeared some months before the publication of the Jubilee Volume, the specific name proposed by Vidyarthi has priority. Vidyarthi, being unable to interpret correctly many anatomical features of the parasite, assigned the species to the genus *Proalarioides* Yamaguti, but the correctness of this was very much doubted by Dubois (1938). The writer (Bhalerao, 1938) assigned it to the new genus *Travassosstomum* which differs in many respect from *Proalarioides*. The writer has, moreover, given a fuller account of this parasite and suggested the inclusion of the genera *Travassosstomum* and *Proalarioides* in the new subfamily Travassosstominae. He has also pointed out the impropriety of including *Proalarioides* in Ophiodiplostominae as was proposed by Dubois (1936). The writer's material was obtained in Nagpur while that of Vidyarthi was collected at Allahabad.

56. Verma (1936 b) records his having obtained some specimens from the Black-necked Stork resembling the species *Holostomum serpens* which is a synonym of *Nematostrigera serpens* (Nitzsch, 1819) Sandground, 1934. The author has not studied these specimens fully and for this reason it is not possible to state whether the specimens belong to one of the already known species or to a new one, and the decision must wait further study.

57. *Cyathocotyle calvusi*.—This species obtained from the intestine of the king vulture (*Sarcogyps calvus*) in Allahabad was briefly described by Verma (1936 b). He does not make any mention of the ventral sucker nor does he show it in the figure. This structure is therefore

presumably absent in this species. As remarked by Dubois (1938), the elongated nature of the testes appears to have been the effect of the similar disposition of the parasite.

58. *Gogatea serpentium*.—Gogate (1932) described this species from the intestine of *Natrix piscator* in Rangoon and assigned it incorrectly to the genus *Prohemistomum*. Lutz (1935) created the new genus *Gogatea* for its reception. Dubois (1938), who examined two specimens of this species, remarks that he has not seen the median cleft of the hold-fast organ described by Gogate as a "narrow central depression."

59. *Mesostephanus burmanicus*.—Chatterji (1940) described this species from the intestine of *Enhydryis enhydryis*, a snake in Burma. The previous members of this genus have been recorded either from mammals or birds. The discovery of a species of this genus in a reptilian host disproves the rigid views of host specificity held by Dubois. The dimensions of the caudal appendage and ventral sucker published by Chatterji appear to be wrong in some respects. Although the author has separated this species from *M. appendiculatoides* (Price, 1934) there do not seem to be clear-cut differences between the two species. Examination of some more material might prove that the two species are identical.

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# THE EMBRYOLOGY OF THE INDIAN APPLE-SNAIL, *PILA GLOBOSA* (SWAINSON) [MOLLUSCA, GASTROPODA].

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## I. INTRODUCTION.

### *General.*

Our knowledge of the embryology of the Gastropoda dates from the latter part of the 19th Century, and a considerable amount of work has been published on the subject. A perusal of the literature shows that while a great deal of attention has been paid to the phenomena of cleavage and cell-lineage, equal justice has not been done to organogenesis. Most of the investigations are confined to the early development of the embryo up to the gastrula or the trochophore stage. Only a few authors have described the origin of the rudiments of the various organ-systems and their subsequent development.

The Indian Apple-Snail, *Pila globosa* (Swainson), is studied as a type of the Gastropoda in many of the Indian Universities, and an account

of its anatomy was published by Prashad (1932). In order to complete our knowledge of this form I took up at Professor K. N. Bahl's suggestion, the study of its embryology.

This investigation was carried out in the Zoology Department of the University of Lucknow under the guidance of Professor K. N. Bahl, D.Sc. (Oxon.), to whom I am deeply indebted for advice and constant encouragement. He made valuable suggestions and took great pains in revising the manuscript. I am also indebted to Dr. M. L. Bhatia and Dr. S. M. Das for their helpful criticisms and assistance in the preparation of the figures. My thanks are also due to Dr. S. M. Sane and Dr. A. C. Chatterjee of the Chemistry Department for translating the bulk of the German references for me; and to Mr. Natu for help in the preparation of some of the drawings. Finally, to Professor E. S. Goodrich, F.R.S., of Oxford, I am deeply indebted for examining the manuscript critically.

#### *Material and Technique.*

The material for the present investigation was obtained during the monsoon months of July and August. Freshly laid spawn was obtained both from Chinhāt and Marayāon Lakes in the vicinity of Lucknow, as well as from the aquarium of the University Zoological Laboratory at Lucknow, where copulating pairs were brought and kept for the study of oviposition. The time taken for oviposition was recorded. The egg-masses were kept on moist earth in large glass dishes in as natural surroundings as possible in the laboratory. The earliest embryonic stages were dissected out of the eggs in normal salt solution by removing a part of the egg-shell and incising the thick solid layer of albumen with a needle, thus allowing the albuminous fluid within to flow out of the egg along with the contained embryo. The embryo was then separated from the albumen with fine needles.

The material was fixed variously. For a study of the cleavage, the segmenting ova were fixed in Gilson's mixture or 5 per cent. formalin, or according to Wilson's method (1904) fixing in acetic acid to which drops of glycerine were added to render the ova transparent. Gilson's mixture was found quite satisfactory for the study of whole embryos. For advanced stages of the embryos, Kleinenberg's picro-sulphuric acid, Gilson's mixture, the Petrunkevitch's mixture, 5 per cent. formalin, Zenker's fluid, and hot corrosive sublimate were employed. Of these Gilson's mixture and the Petrunkevitch's mixture gave the best results.

The time of fixation varied with the different fixatives and with the different stages of development. Gilson's and Petrunkevitch's mixtures required 5 to 20 minutes.

In advanced stages when the shell is well developed and the embryos possess an adult appearance, it is always essential to fix them in their fully extended condition in order to avoid complications caused by the retraction of the embryo within the shell. For this purpose, the embryos were narcotised either with sulphuric-ether or with chloroform. The shell was then removed with fine needles.

The fixed material was stored in 75 per cent. alcohol. Some of the material was preserved in the alcohol-glycerine mixture. It was found,

however, that the glycerine penetrated the tissue of the material so thoroughly that it could not be completely removed subsequently, with the result that good sections could not be obtained.

It may be emphasised that material should preferably be kept in glass-stoppered tubes rather than in corked tubes. In the latter case, presumably on account of some chemical change produced by the action of alcohol on the cork, the material becomes discoloured, and does not yield good sections, as the cells of the outer or epidermal layer become vacuolated, shrunken or distorted. On the other hand, the material kept in glass-stoppered tubes retains its natural colour for a long time and the tissues remain in good condition.

For whole mounts, the best results were obtained by first keeping the embryos in the alcohol-glycerine mixture for some time. This treatment renders them more transparent than is otherwise possible. Embryos as well as the early eggs in cleavage-stages were cleared in clove oil and mounted in cavity slides - which procedure has the advantage that, on rolling the cover-slips, the ova and the embryos can be examined on all sides without being injured.

For sectioning, the embryos were cleared in cedar-wood oil and embedded in paraffin. For the orientation and the block-making of very early stages, the following method proved to be satisfactory. The embryos were transferred from the clearing medium on to a piece of blotting paper, whence they were transferred by touching the embryos with a needle dipped in melted paraffin, when the embryos adhere to the paraffin. They were then transferred to watch glasses containing molten paraffin inside the bath. At the time of block-making, the embryos were orientated under the binocular-microscope and the paraffin allowed to cool. If the material is lightly stained with Borax Carmine while it is still in alcohol, the orientation in paraffin is very much facilitated.

Sections were cut in three planes, *viz.*, transverse, sagittal, and horizontal. Sections of the early stages were cut 5 $\mu$  thick, but those of some of the advanced stages were cut up to 8 $\mu$ .

Whole mounts were stained in alcoholic borax-carmine which was also used as a bulk stain for sectioning purposes. Delafield's Haematoxylin, either alone or with eosin as a counter-stain, and Heidenhain's haematoxylin were employed for staining the sections.

All figures were drawn with the help of the camera lucida. The figures of the whole mounts were drawn in outline with a camera lucida, but the outlines of the internal organs, though first traced from whole mounts, were checked later by a study of the sections. The figures have been so drawn that the dorsal side of the animal is the upper side of the section, and thus the direction of the foot is always kept ventral. In figures of transverse sections, the right and left sides of the figures correspond to the right and left sides of the animal.

## II. OVIPOSITION.

### *The General Process.*

Like most Gastropods, *Pila globosa* is oviparous. It breeds during the rainy season, which in Northern and Eastern India extends over a period of about four months, from June to September. In the United

Provinces, the period extends from the beginning of July to about the first week of September, but the middle of July, when the monsoon is in full swing, is the most active period. In Bengal, where the monsoon is early, breeding takes place in May and June (Prashad, 1925). Breeding depends not only on the onset of the rains but also on their continuity. If there is a break in this continuity for several days on end, breeding ceases altogether, except in rare cases.

As soon as the rains set in, the snails, which have been aestivating underground upto a depth of four feet (Bahl, 1928), come out of the ground and enter small ponds and puddles formed by the rain. They feed voraciously on succulent aquatic plants such as *Vallisneria* and *Pistia*, and later copulate. Copulation may take place either in water while the snails are floating, or near the edge of water amongst water-weeds.

Eggs are laid two to three days after copulation, and generally about two weeks elapse after the onset of the rains before the females are seen laying their eggs. According to Bahl (1928), oviposition can be delayed by preventing impregnated females from going out of water on to the land, but when this check is removed, oviposition begins. He writes, "after keeping several fertilised females in water in a glass aquarium for a week, I took them out and placed them on moist ground in the frog-pond with the result that there was, so to speak, an 'epidemic' of oviposition, since all of them had been waiting to lay eggs". I observed also that females, which were disturbed in the act of oviposition, if kept on moist soil, started laying again after about three hours, so that the interrupted oviposition was resumed.

Generally, *Pila* lays its eggs in the early hours of the morning from about 5 to 9 A.M., though sometimes eggs are laid at other hours of the day as well.

For oviposition, *Pila* leaves the water and comes out on the land. It lays its egg-mass in a suitable place, generally a few inches to a few feet above the water-margin in a natural depression in the ground or a special pit made for the purpose in soft ground with the help of its shell and foot. When the ground is hard, no pit or depression is formed and the eggs remain quite exposed and unprotected, but they are usually concealed amongst water-weeds or grass close to the water-margin.

There are two distinct advantages to the snail in laying the egg-masses amongst water-weeds rather than on open ground. In the first place, the eggs are protected from desiccation; they retain their moisture for a long time, and even the outermost eggs in the mass do not dry up; the number of embryos which hatch out is much larger than in the case of those egg-masses which are laid out in the open. In the latter case, there is exposure to direct sunlight and excessive evaporation with the result that the outer layers of eggs in the masses dry up and the embryos die.

When *Pila* comes out of water for oviposition, a process which takes four to six hours, it is exposed to its enemies, such as water-birds, specially the herons, which are always on the look-out for and pounce upon the snail, which has protruded its foot and head out of its shell and lies in a relaxed condition during oviposition. These birds tear the snail

out of its shell and incidentally destroy the eggs, trampling them under their feet.

During oviposition, the head region protrudes out of the shell along with the fully extended foot, the latter functioning as an 'ovipositor' (Bahl, 1928) by being transformed at its base into a cup-shaped structure with the concavity towards the outside. By its muscular action, the foot helps in the deposition and collection of the eggs into a mass as soon as they pass out of the vagina, one after another. The cup-shaped foot envelopes the eggs as they are laid and keeps them together till the last egg is laid, after which the female withdraws its foot from the egg-mass and creeps back to the water, leaving the egg-mass outside. It was probably after seeing *Pila* in such a state, i.e., when the female was laying its eggs and the eggs were partially covered by the dome-shaped sole of the foot, that Ramanan formed a wrong idea that eggs were being incubated by the female; he also wrongly considered the upper part of the cup-shaped foot enveloping the egg-mass as a part of the mantle. Bahl (1928) first showed that Ramanan was mistaken; and I agree with him. Bahl's statement that "the foot is attached to the egg-mass for kneading together and adding new eggs as they are being laid to the pre-existing egg-mass and not for the purpose of incubation" is corroborated by my own observations.

#### *The Egg-Mass.*

The eggs are laid in more or less irregular masses which differ in size, weight, and shape, and also in the number of eggs they contain. The size of the egg-mass varies from  $2 \times 2.5$  cm. to  $5 \times 9$  cm., averaging about  $3.5 \times 5$  cm.; the eggs are placed 5 to 6 layers deep. The weight of the egg-masses varies from 5 to 34 grms., average 15 to 25 grms. The number of eggs in each mass varies from 100 to 850; in masses which are about  $3.5 \times 5$  cm. in size and 15 to 25 grms. in weight, the number is from 400 to 500.

The shape of the egg-masses varies. If the eggs are laid in a hollow, the mass assumes a convexity on the side lying against the ground. On flat ground, the mass is flat on the lower side. The upper surface of the mass may be either flat or convex. The mass is more or less circular or oblong in outline and may show a depression in the centre.

During oviposition, as the eggs are laid in succession and are sticky in the fresh condition, they get pressed and glued together due to the muscular action of the foot. The eggs thus become slightly flattened at their places of contact.

#### *The Egg.*

The eggs of different masses may vary slightly in size, but the eggs of the same mass are of the same size, though in a few cases one or more eggs in the same mass may be larger than the rest. The egg is either rounded or oval in shape, varying in diameter from 4 to 7 mm., the latter size being rare. The average diameter is about 5 mm.

The egg is composed of a shell; two thin membranes, the shell-membrane and the albumen-membrane; a solid albuminous sphere; and the albuminous fluid in which the embryo floats.

The shell forms the outermost covering of the egg. It is calcareous and is milk-white in colour ; when fresh it is soft and sticky. Shortly after oviposition, the shell dries up and becomes hard and brittle. The shell is also porous. The outer surface of the shell is rough and is studded with minute tubercles. The shell is about 0.5 mm. thick and is lined internally with a very thin and delicate transparent membrane, the shell membrane. On removing the shell with the shell membrane, a thick solid globular mass, the albuminous sphere, is seen. It is about 4 mm. in diameter and 1.2 mm. thick, and fills the entire space within the shell. Closely investing the albuminous sphere, is another delicate membrane, the albumen-membrane. The albuminous sphere is solid in texture, and is greyish-white in colour ; inside, it is hollow and the cavity is filled with a transparent albuminous fluid in the centre of which floats the yellowish embryo. The area covered by the albuminous fluid is about 1.7 mm. in diameter.

The growing embryo ingests the entire albuminous fluid and then the solid albumen, so that at the time of hatching, only the albumen and shell-membranes are left within the shell ; the latter ruptures to allow the embryo to come out.

Development evidently begins as soon as the eggs are laid. Eggs taken from different regions of an egg-mass contain embryos at different stages of development. In a freshly laid egg-mass, the eggs laid last show no cleavage of the fertilised ovum at all ; the eggs from the middle layers of the egg-mass are in the two cell stage ; and the eggs that were the first to be laid, *i.e.*, those at the lowermost layer of the egg-mass, are already in the four to eight-cell stages.

Apparently, all the eggs are fertilised, and are capable of development under favourable conditions ; no sterile eggs were met with<sup>1</sup>.

The incubation period varies with the nature of the environment. Brighter sunshine (higher temperature) and suitable humidity accelerate development. I found that in one year when the temperature in the shade varied between 90 to 100°F. the incubation period was 10-14 days ; while in another year, during the corresponding period when, due to constant and heavy rainfall, the temperature had come down to 70-80°F. the incubation period was about three weeks<sup>2</sup>.

### III. THE FERTILISED OVUM.

During copulation the spermatozoa are known to make their way to and impregnate the ova while the latter are still within the oviduct. The thick solid layer of albumen and the egg shell are formed later and surround the fertilised ovum. Careful examination of a freshly laid egg, on the removal of the egg-shell and the solid albumen-sphere, shows a large number of spermatozoa floating in a more or less disintegrated condition in the liquid albumen (*cf.* Semper, 1862 ; Scott, 1934).

<sup>1</sup> According to Annandale (1920) a covering of the sterile eggs surrounding the fertile ones is met with in the case of the Siamese species, *Pila turbinis*.

<sup>2</sup> Prashad (1925) gave the incubation period in *Pila globosa* as about a month. In *Ampullaria polita*, according to Semper (1862), 14 days was the maximum period required by the young ones to hatch out. Scott (1934) gives this period as about one month in the case of *Ampullaria canaliculata* but this, she says, is the case with eggs produced at the end of the season and kept in shade.

The fertilised ovum (Text-fig. 1a) is spherical, and is a bright lemon-yellow due to the presence of the coloured food-yolk which renders the egg quite opaque. Each ovum in the living state is about  $160\ \mu$  in diameter<sup>1</sup>. In it the yolk is uniformly distributed and there is no demarcation between the protoplasmic and deutero-plasmic portions. The first indication of a polar differentiation is noticed when the two polar bodies are extruded, one after the other, at one end of the egg, which forms the animal or formative pole of the egg. In *Pila globosa*, as in *Paludina* (Tönniges, 1896) and *Crepidula* (Conklin, 1897) the polar bodies do not remain attached to the egg for a very long time, but soon get detached and disappear<sup>2</sup>. On examining the ovum immediately before the first cleavage, we find that just beneath the polar bodies there lies a small comparatively lighter area, while the yolk is concentrated at the opposite end of the egg; the nucleus has moved from its middle position into the animal pole while the polar bodies are being extruded. Thus a polar differentiation is clearly established in the egg just before cleavage starts, as is generally the case in all Gastropoda. In *Crepidula*, however, Conklin (1897) believes that this polarity is established at a very early stage when the egg is still within the ovary.

#### IV. CLEAVAGE AND THE CLEAVAGE=CAVITY.

##### *The First Cleavage.*

Cleavage begins about  $2\frac{1}{2}$  to 3 hours after the eggs are laid. The first dividing furrow appears at the animal pole where the polar bodies were extruded, and gradually extends along both sides in a meridional direction to the vegetative pole. The first cleavage is completed in about 15 minutes and divides the egg into two equal halves, the blastomeres. Each hemispherical blastomere soon becomes almost spherical again, the two being joined along a small area in the middle of each sphere. But this spherical shape does not persist, as the blastomeres again become flattened against each other (Text-fig. 1b), so that the two together look like a single undivided sphere (cf. *Paludina*, *Littorina*, *Succinea*, *Crepidula*, *Limax*, *Planorbis*, *Physa*, etc.).

At the junction of the two blastomeres a lenticular cavity makes its appearance and after reaching its maximum size, suddenly disappears before the commencement of the next cleavage.

##### *The Second Cleavage.*

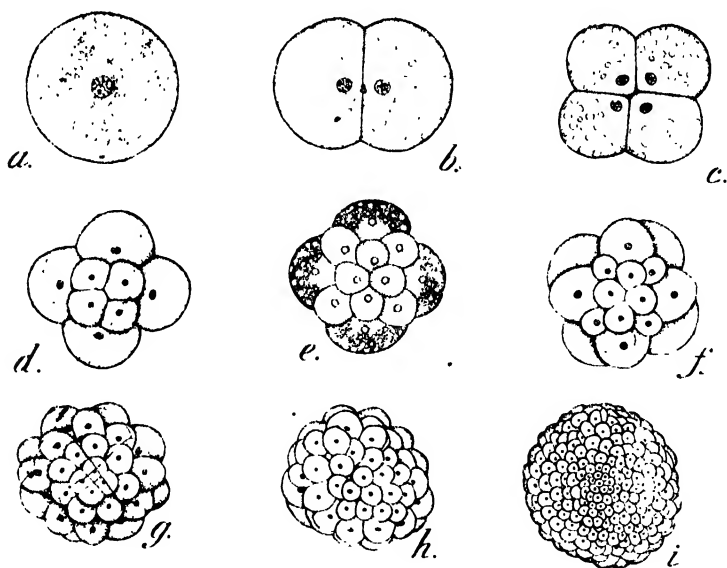
The second cleavage occurs about two hours after the completion of the first. Just before the appearance of the second cleavage-furrow, the two hemispherical blastomeres show the same arrangement of their contents as in the unsegmented ovum, i.e., the clear protoplasmic area with the nucleus lies towards the animal pole, while the yolk is concentrated towards the vegetative pole. This cleavage is also meridional.

<sup>1</sup> I have observed that on fixation the ovum shrinks in size. Thus, for example, a living fertilised ovum about  $160\ \mu$  in diameter became reduced to  $144\ \mu$  in diameter, after it was fixed, dehydrated and cleared.

<sup>2</sup> Conklin (1897) has traced these polar bodies in *Crepidula* inside the mesenteron, where they had "been drawn in with the nutrient fluid (albumen) surrounding the embryo".



Beginning from the animal pole, it cuts across the first furrow at right angles, and gives rise to four blastomeres of equal size, designated as A, B, C and D. The division of the two blastomeres occurs simultaneously and I never came across any stage where the division of one of the two blastomeres preceded even slightly that of the other. At the time of their formation, the blastomeres are, as in the preceding stage, spherical but later get pressed against one another (Text-fig 1c). The second cleavage is the first indication of the occurrence of the 'spiral' cleavage and is *laevotropic* in direction. It occurs in such a manner that 'cross' or 'polar' furrows are formed at the two poles of the segmenting egg, as a result of which two of the blastomeres come to lie against each other at one pole and prevent the other two from coming in contact with each other; the latter two however, meet at the opposite pole (Text-fig. 1c) where the first two remain apart. The polar furrow is of great practical and theoretical importance. It has been stated to bear a constant relation, in all cases of spiral cleavage, to the first and second cleavages. If an egg at the 4-cell stage is seen from the animal pole, the polar furrow is seen bending to the right if the first cleavage-furrow be kept in the line of vision, and in the reverse direction, *i.e.*, towards the left, if the second furrow is kept in the line of vision. This order is reversed if we see the segmenting egg from the vegetative pole. According to Conklin (1897) and others, the segmenting egg can be easily and rightly orientated, even in its later stages, by keeping this early position and condition of the polar-furrows in mind.



TEXT-FIG. 1. Early cleavage stages up to the formation of the blastula:  $\times 200$

a. Fertilised ovum as seen from the animal pole:  $\times 200$ .

b. 2-cell stage. c. 4-cell stage. d. 8-cell stage. e. 12-cell stage. f. 16-cell stage. g. 32-cell stage. h. 48-cell stage. i. Surface view of a fully developed blastula as seen from the animal pole:  $\times 200$ .

At this stage again, a quadrilateral cavity makes its appearance in the centre of the egg where the four blastomeres meet, and, after reaching its maximum size, suddenly disappears just before the formation of the third cleavage, in exactly the same manner as in the preceding stage. It reappears again after the next cleavage is completed and disappears after a short pause, to repeat the process in the following cleavages. It is the rudiment of the cleavage-cavity, and has been rightly described by Kofoid (1895) as "an ephemeral recurrent cleavage-cavity".

*The third cleavage or the formation of the first quartette of micromeres.*

Unlike the first two, the third cleavage-furrow, formed after an interval of 1 to 1½ hours, is equatorial in direction and lies more towards the animal pole. It cuts off four small protoplasmic micromeres from the four large macromeres in which the yolk-material is now concentrated, thus giving rise to the 8-cell stage (Text-fig. 1d). The four micromeres, designated as *a*, *b*, *c* and *d*, form the first quartette<sup>1</sup> of micromeres or the ectoblast. The spiral cleavage is more pronounced at this stage and the actual rotation of the cells, *1a*, *1b*, *1c* and *1d*, towards the right side can be easily seen; this cleavage is *dextrotropic* in contrast to the preceding *laevotropic* one. The micromeres rotating approximately through 45° come to lie finally on the furrows between the macromeres. After the rotation, the micromeres draw together, get pressed against one another and lose their spherical shape. A "secondary" polar furrow is formed in the centre where the cells meet. A central cleavage-cavity also makes its appearance at this stage but after attaining its maximum size disappears before the commencement of the next cleavage.

*The formation of the second quartette of micromeres.*

The next cleavage results in the formation of a 12-cell stage (Text-fig. 1e). The four micromeres of the second quartette are cut off from the macromeres; these micromeres, *2a*, *2b*, *2c* and *2d*, are smaller than the macromeres *2A-2D*, but are distinctly larger than the micromeres of the first quartette (*1a-1d*). The 12-cell stage is not a "transitory" stage but a "resting stage" in *Pila*. After the cleavage is completed the blastomeres draw together and give the segmenting egg a spherical form. An "ephemeral recurrent" cleavage-cavity again makes its appearance to disappear again at the time of the next cleavage.

*The division of the first quartette of micromeres.*

After a pause of about half an hour the cells of the first quartette (*1a-1d*) divide unequally into double their number. This cleavage is again anti-clockwise or *laevotropic*. The daughter-cells which are cut

<sup>1</sup> The term 'quartette' is used to designate the products of one 'generation' of the egg, which are cut off at the animal pole from the four cells lying below. The subdivisions of these quartettes will be described as "tiers"—those which are cut off towards the animal pole form the 'upper tier', while those towards the vegetative pole form the 'lower tier'.

Similarly, the quartettes of the different 'generations' are designated by co-efficients (*1a*, *2a*, *3a*, etc.), while the genealogy of the cells of each quartette is indicated by exponents (*1a*<sup>1</sup>, *1a*<sup>2</sup>, *1a*<sup>11</sup>, *1a*<sup>21</sup>, *1a*<sup>111</sup>, *1a*<sup>112</sup>, *1a*<sup>211</sup>, *1a*<sup>212</sup>, etc.).

off towards the animal pole from the "upper tier" of micromeres, namely,  $1a^1$ ,  $1b^1$ ,  $1c^1$ ,  $1d^1$  and are pushed towards the periphery. Conklin (1897) calls these peripheral cells ( $1a^2$ - $1d^2$ ) "the turret-cells". Thus a 16-cell stage is reached (Text-fig. 1f).

*The formation of the third quartette of micromeres.*

The formation of the third and last quartette of micromeres ( $3a$ - $3d$ ) occurs almost simultaneously with the first division of the second quartette of micromeres, with the result that a 24 cell stage is obtained. At first, four micromeres ( $3a$ - $3d$ ) are separated off from the macromeres ( $3A$ - $3D$ ) in a dextrotropic direction, and this is immediately followed by the dextrotropic division of the micromeres of the second quartette ( $2a$ - $2d$ ), so that a 20-cell resting stage never results, and we get directly to the 24-cell resting stage. The micromeres of the third generation are fairly large but are smaller than the macromeres, and are distinguished from the latter by their clear protoplasm. At this stage the first quartette consists of 8 cells in two tiers: (1) the upper tier ( $1a^1$ - $1d^1$ ) in the centre looking more or less like a cross; and (2) the lower tier ( $1a^2$ - $1d^2$ ) (turret-cells or trochoblasts) lying in the angles of the arms of the cross of the upper tier. The second quartette of micromeres also consists of 8 cells ( $2a^1$ - $2d^1$  and  $2a^2$ - $2d^2$ ). Beneath these lie the cells of the third quartette which are only 4 in number, and lie in the furrows of the four macromeres still laden with yolk and forming the vegetative pole of the embryo. A cleavage-cavity now appears which, unlike the preceding ones, does not disappear but persists throughout the later stages, and forms the cleavage-cavity of the blastula.

These three quartettes represent the ectoderm and mark the complete separation of the ectoderm from the endoderm and mesoderm, both of which are represented by the four macromeres.

In the 32-, 48- and 64-cell stages (Text-figs. 1g, h) as in the earlier ones the cells of the segmenting egg come together after the completion of the divisions, and get pressed against one another so that the egg assumes a spherical shape and the outlines of the cells are lost, making it difficult to count their number. In these stages, neither sections of embryos nor whole mounts show any indication of the differentiation of the primary mesoderm cell which has been traced in many Gastropoda to the 24-cell stage, as in *Crepidula*, *Planorbis*, and others. The earliest trace of the mesoderm in *Pila*, as in *Paludina*, appears much later, viz., in the gastrula stage.

The micro- and macromeres increase in number and the cleavage-cavity expands till a blastula with a distinctly large blastocoele is formed. A fully developed blastula (Text-fig. 1i) is a spherical structure, about 0.16 mm. in diameter, with the micromeres at the animal pole and the macromeres at the vegetative pole. A blastula is formed in about 19 to 21 hours after the eggs are laid.

I have not been able to ascertain with certainty whether the albumen is deposited first in the micromeres or in the macromeres, or simultaneously in both. I observed it only at a stage when it was already present in all the blastomeres. After the gastrula stage, however, the albumen is absorbed by the endodermal cells alone.

*Discussion.*

The study of the cleavage in *Pila* shows that it resembles other Gastropods in which the eggs do not contain a large amount of yolk, as in *Ampullaria canaliculata* (Scott, 1934). The spiral cleavage in *Pila* at the 4-cell stage is characteristic of all Gastropods. Again, in the direction of its polar furrow, *Pila* resembles all other dextral Gastropods such as *Crepidula* (Conklin, 1897) and *Umbrella* (Heymons, 1893). In sinistral Gastropods such as *Planorbis* (Rabl, 1879; Holmes, 1900) and *Physa* (Crampton, 1894; Wierzejski, 1905) the direction of the polar furrow is the reverse.

In most Gastropods the blastomeres up to the 4-cell stage are, as in *Pila*, nearly of equal size, and inequality first becomes evident in subsequent cleavage stages. In *Aplysia* and *Acrea*, however, the blastomeres are unequal already in the 4-cell stage.

Among Gastropods the amount of yolk seems to play an important rôle in regard to the relative size of the micro- and macromeres. The greater the amount of yolk in the egg, the smaller are the micromeres in relation to the macromeres, and this relation is maintained in the later stages of cleavage. In eggs with little yolk this difference is ill-marked, and later all the blastomeres apparently become equal in size.

In *Pila globosa* the micromeres of the 3rd quartette (3a-3d) are distinctly smaller than the macromeres, though the difference is not considerable.

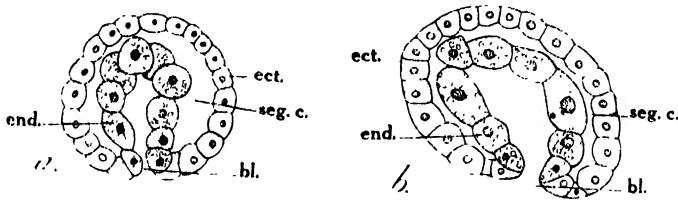
I agree with Delsman's view (1914) that the diameter of the eggs is no measure for gauging the amount of food-yolk present in them. He has shown that though in *Littorina obtusata* the egg is 200  $\mu$  in diameter as compared with 112  $\mu$  in *Crepidula fornicata* (Conklin, 1897), the inequality of cleavage is much more marked in the latter than in the former, as shown by the micro- and macromeres of the 3rd quartette. In *Pila globosa* the egg-diameter is 160  $\mu$ , yet there is great inequality in the size of the micro- and macromeres, though this is not so pronounced as in *Crepidula*.

*The cleavage-cavity.*

The cleavage cavity first appears as a small lenticular cavity in the 2-cell stage at the region where the two blastomeres meet; after attaining its maximum size, it suddenly disappears, the blastomeres get closely pressed against each other and are ready for the next cleavage. It reappears in the 4-cell stage as a central quadrilateral cavity formed at the meeting-place of the inner ends of the four blastomeres. The cavity gradually enlarges till the blastomeres get flattened along their inner surfaces and give the segmenting egg a spherical shape just before the third cleavage. Now the cavity disappears to appear again at the 8-cell stage. This process of appearance and disappearance continues till the 24-cell stage is reached, when the cavity no longer disappears but persists, and gradually enlarges till it assumes a considerable size within the fully developed blastula. In its early stages the cleavage-cavity lies more towards the animal pole of the developing egg.

## V. GASTRULATION.

The fully developed blastula becomes flattened at its thickened vegetative pole. The macromeres at this thickened region become elongated and extend into the segmentation-cavity. Gradually a depression appears at this thickened region, the depression being deeper towards the centre than towards the periphery. As development proceeds the depression deepens, thereby pushing the elongated cells of the flattened region deeper into the segmentation-cavity and leading to the invagination of all the macromeres at the vegetative pole to form the future endoderm. Thus arises the gastrula (Text-figs. 2*a*, *b*) and the place of invagination forms the blastopore. Gastrulation in *Pila* is, therefore, embolic. The edge of the blastopore marks the boundary between the micromeres (ectoderm) and the yolk-laden macromeres (endoderm). The endoderm cells, in addition to their larger size, can be easily distinguished from the ectoderm cells in taking a lighter stain because of the presence of yolk within them.



TEXT-FIG. 2. Gastrulation.

*a.* Horizontal section of an early gastrula:  $\times 280$ .

*b.* Optical horizontal section of an older gastrula:  $\times 487$ .

Unlike some other Gastropoda such as *Paludina*, the segmentation-cavity in *Pila* is never obliterated completely at gastrulation, but is merely reduced and later again enlarges.

When invagination is complete, it is seen that the invaginated endoderm or archenteron is enclosed on two sides by the two arms of the mesodermal bands which, though separate from each other anteriorly, converge posteriorly at their place of origin from the mesodermal teloblasts.

In the early stages of invagination the gastrula appears more or less kidney-shaped in a lateral view. On further growth, however, it reassumes the spherical shape of the blastula. The blastopore is large in its earlier stages, but becomes smaller and smaller until finally it becomes greatly reduced.

The lumen of the archenteron is not simple, but right from the time of the invagination the endodermal wall becomes folded and the archenteric cavity gives rise to either two or more accessory chambers of different sizes and shapes. These chambers communicate with the central cavity of the archenteron through narrow or wide passages. Thus, in some cases one gets the impression that the accessory chambers are evaginations from the main central lumen of the archenteron. *These evaginations simulate archenteric pouches which are liable to be mistaken for coelomic pouches.* The infoldings of the archenteric wall provide a large surface evidently for the assimilation of the ingested albumen.

## VI. THE TROCHOPHORE.

As the gastrula assumes its final, more or less bell-shaped, form, the blastopore becomes narrowed to such an extent that it is difficult to locate it in sections which are even slightly oblique. In the living condition, the presence of yolk within the endoderm cells renders the gastrula quite opaque and yellow, so that the blastopore cannot be seen. The invaginated archenteron becomes more or less flask-shaped- the part around the blastopore is narrow, while that at the opposite end is broad and has a wider lumen. The part of the embryo away from the blastoporal end is the anterior one while the blastoporal end forms the posterior end. The blind end of the archenteron widens out and, consequently, the cleavage cavity becomes reduced in that part of the embryo, while in its posterior part, it remains quite spacious. A further differentiation takes place in the embryo at this stage: an equatorial band of two rows of cells, situated more towards the anterior end than in the middle, becomes differentiated by an increase in size of these cells and encircles the embryo. As development proceeds, the cells of this band grow in size and become fairly prominent. Vacuoles appear within these cells giving the latter a more or less transparent appearance. Later, fine cilia develop on these cells and the ciliated band forms the velum; and thus the embryo passes into the trochophore stage. At this stage neither the rudiment of the stomodaeum nor that of the foot has differentiated. The blastopore, however, persists as a narrow aperture and forms the anus, while the mouth is a new formation. At the posterior end, on that side of the embryo which in later stages becomes the dorsal side, a flattening of the ectodermal wall takes place; this marks the area where, after a short time, the thickened rudiment of the shell-gland makes its appearance.

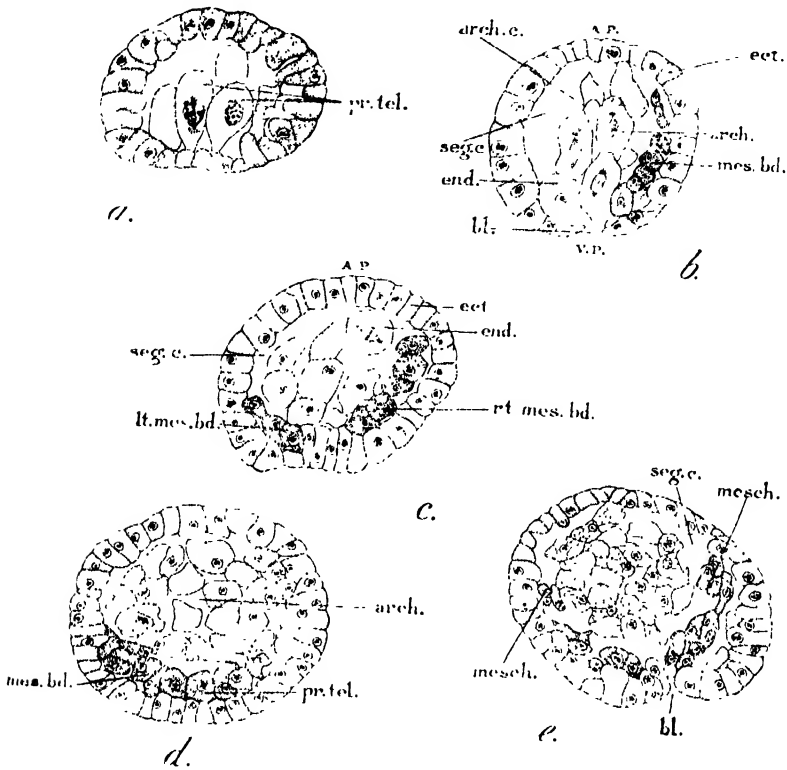
VII. THE DEVELOPMENT OF THE MESODERM (TEXT-FIGS. 3*a-c*).*The Development.*

The earliest stage examined by me regarding the origin of the mesoderm is an early gastrula as shown in text-fig. 3*a*. Here the mesoderm is represented by two large bilaterally arranged cells, the mesodermal teloblasts. These two cells, which lie side by side, are slightly larger than the endoderm cells and have distinct and large nuclei. They lie close to and immediately posterior to the position of the blastopore. From their position, structure and size I conclude that they (teloblasts) are derivatives of one of the posterior macromeres. The mother mesoderm cell presumably migrates inwards and comes to lie within the segmentation-cavity where, in the stage available to me, that cell has already divided into two.<sup>1</sup>

As development proceeds these two teloblasts divide in such a manner that the daughter cells lie on the right and left sides of the median axis passing through the blastopore. They thus form paired bands, each

<sup>1</sup> Unfortunately all the well-fixed embryos I have sectioned represent stages later than the stage in which the primary or mother mesoderm cell might be seen either migrating into the segmentation-cavity (after its abstraction from one of the macromeres) or lying free within the cavity after migration.

consisting of a row of cells in single file. These are the mesoblastic bands. At first each band consists of a few cells only, but as development pro-



TEXT-FIG. 3. Development of the mesoderm.

*a.* Horizontal section of an early gastrula, passing through the two primary mesoderm cells or teloblasts:  $\times 264$ ; *b.* Oblique horizontal section of an embryo slightly older than in (*a*), passing through the blastopore and showing the mesoblastic band on the right side:  $\times 256$ ; *c.* Horizontal section of a gastrula, showing the mesoblastic bands in the form of a single row of cells:  $\times 256$ ; *d.* Horizontal section of a gastrula older than in (*c*), showing the thickening of the mesoblastic bands. The primary teloblasts are still distinct and are distinguishable by their large size:  $\times 260$ ; *e.* Horizontal section of an embryo about the trochophore stage, showing the differentiation and detachment of the spindle-shaped mesenchyme cells from the mesoblastic bands:  $\times 268$ .

ceeds, the bands increase in length and in the number of their constituent cells. The growth of each band proceeds towards the anterior end of the embryo. In early stages the primary teloblasts, from which the bands are formed, remain quite distinct and are larger than the rest of the mesodermal cells in the bands, and they remain at the posterior end of the embryo; but in later stages the teloblasts cannot be distinguished from the other cells of the mesoderm bands. The cells of the mesoblastic bands can be easily differentiated from the endoderm cells: firstly, by their more or less cubical shape and smaller size as compared with the rounded or oblong shape and larger size of the endoderm cells, and secondly, by their taking a deeper stain than the endoderm cells, because of the absence of yolk and other fatty substances in the contents of their cytoplasm.

As development proceeds the mesodermal bands become thickened by an increase in the number of their cells. The shape of the mesodermal cells also undergoes a change ; they gradually lose their cubical form and become stellate in appearance.

With further development the mesodermal cells at the anterior ends of the bands become detached and come to lie scattered within the segmentation-cavity as spindle-shaped mesenchyme cells.

#### *Discussion.*

The origin of the mesoderm in *Pila* is teloblastic, thus resembling the condition most commonly met with in a large majority of Gastropods in particular, and in the Mollusca in general. In all those cases where particular attention has been paid to the study of cell-lineage, it has been found that the mother mesoderm cell can be traced to one of the posterior macromeres, namely 3D the left posterior one in dextral and the right posterior one in sinistral forms (Crampton, 1896).

A comparative study of the earlier accounts of the origin of mesoderm in Gastropoda shows that besides the abovementioned teloblastic type, two other types have been described, *viz.*, ectodermal and enterocoelic.

In the first type, the mesoderm is said to arise directly from the ectoderm, as in *Fusus* (Bobretzky, 1877), *Vermetus* (Salensky, 1885), and *Paludina* (Tönniges, 1896 ; Dautert, 1929). According to Tönniges (1896) and Otto and Tönniges (1905) the mesoderm in *Paludina* originates by a wandering in of the ectodermal cells into the segmentation-cavity from the place where the blastopore has closed. MacBride (1914) denies the accuracy of Tönniges's conclusions. Dautert (1929), while confirming the ectodermal origin of the mesoderm, holds that the mesoderm originates anteriorly from the ectodermal wall just below the velum and not in the region of the blastopore.

The second or enterocoelic type of mesoderm formation has so far been described only in *Paludina* (Erlanger, 1891 ; Fernando, 1931) which was the form also studied by Tönniges. Erlanger (1891) found that at first a ventral pouch-like outpushing of the archenteric wall takes place close to the blastoporal end, which, on further development, expands laterally into a bilobed outgrowth which later becomes completely detached from the archenteron. This closed bilobed outgrowth represents, according to him, the primary coelomic sacs, the cells of the walls of which break up in later stages to wander into the segmentation-cavity as mesenchyme cells. It was this description of mesoderm formation in *Paludina* which later led to the investigations of Tönniges (1896), Otto and Tönniges (1905) and Dautert (1929) who contradicted Erlanger's statement and expounded, instead, the abovementioned ectodermal origin of the mesoderm. Fernando (1931) recently has confirmed Erlanger's view. He, however, points out that different fixatives lead to different results : thus, Kleinenberg's fixative (which Dautert employed in his investigations) " produces a general loosening of the cells " and " in fact if all the material had been fixed in Kleinenberg's alone, there is little doubt that the result of present investigations would have been to confirm Dautert's view ".



In the present investigation I tried different fixatives like formalin, Flemming's chromo-osmic, Perenyi's fluid, Gilson and Petrunkevitch's mixtures and Kleinenberg's fixative, and found that the different fixatives do act differently on the various germ-layers. I obtained satisfactory results with Kleinenberg's picro-sulphuric fluid, and found that no loosening of cells occurred with this fixative and that the mesoderm could be well differentiated from the other germ-layers. On the other hand, fixatives like Gilson's mixture, Flemming's fluid and others led to a loosening of the cells, with the result that the mesoderm was not well differentiated in its earlier stages of formation. This difficulty in the differentiation of the mesoderm, in fact, misled me, and I at first mistook the pouches formed by the infolding of the archenteric walls (described in section V) as the coelomic pouches described by Erlanger and by Fernando in *Paludina*.

#### VIII. THE GENERAL OUTLINE OF DEVELOPMENT BEYOND THE TROCHOPHORE STAGE.

Before describing the development of the various organ-systems, it will be useful to give a general outline of the development which can roughly be divided into 12 stages.

##### *Stage 1* (Text fig. 4a).

The embryo at this stage is about 36 hours old and about 0.192 mm. in length. It is more or less pear-shaped in outline, slightly elongated antero-posteriorly, the anterior end being spherical while the posterior end is tapering and conical. It is bilaterally symmetrical both externally as well as internally. Externally, the embryo is characterised by the presence of the velum, the foot rudiment, and the shell gland. The velum runs as a transverse ciliated band and delimits the pre-oral (cephalic or velar) area from the post-oral part of the embryo. The cells forming the velum are large, and in the living condition exhibit a glassy transparency on account of the hyaline character of their cytoplasm.

The foot rudiment is a conical outpushing of the mid-ventral area just behind the velum.

On the aboral (dorsal) surface of the embryo, the ectoderm cells behind the velum become columnar and form a circular plate which appears darker in colour on account of the thickly granular character of its cells. It is the rudiment of the shell gland, and is thickest in the middle.

The archenteron occupies a considerable space within the embryo but no differentiation of regions has so far taken place in it. Its anterior spherical end is much broader than the posterior one, which is narrow and forms a straight tube opening to the exterior through the anus formed by the blastopore (Text-fig. 6a). This narrow tube is the rudiment of the intestine. The cells lining the archenteron are full of yolk and thus impart a yellow colour to the embryo.

The ectodermal cells on the ventral surface lying immediately behind the velum multiply rapidly to form a thick plate which sinks below the surface and is pushed inwards. This invagination between the velum and the foot is the rudiment of the stomodaeum.

The mesenchyme cells (Text-fig. 6a) are stellate and lie scattered in the body-cavity between the ectoderm and the endoderm, which is more extensive in the posterior half of the embryo than in the anterior.

### *Stage 2 (Text-fig. 4b).*

The embryo at this stage is about 40 to 45 hours old, and is 0.208 mm. in length. There is no marked change from Stage 1 in the general shape of the embryo, except that the foot-rudiment has become more prominent, although there is as yet no line of demarcation between the foot and the rest of the body either at the anterior end of the foot or along its lateral borders. In fact the walls of the foot pass imperceptibly into those of the head-vesicle (the part of the embryo above as well as anterior to the foot).<sup>1</sup> At the posterior end of the foot, however, there appears a slight depression which, together with the shell-gland on the dorsal side, marks off the posterior part of the embryo, the rudiment of the visceral-sac. On the ventral surface the velum forms an arched lobe just above the stomodaeal opening, thus giving rise to two velar lobes, one on either side of the stomodaeal opening.

The stomodaeum has become deeply invaginated but has not yet opened into the anterior end of the archenteron or primitive stomach (Text-fig. 6b).

A few large, glassy and transparent cells are visible at the extreme anterior end of the dorsal surface just in front of the velar cells: these constitute the *apical cell-plate*. A few ectodermal cells at the ventral conical end of the foot become large in size and develop cilia; Conklin (1897) observed these cells in *Crepidula*, and finding their close resemblance with the cells of the apical cell-plate called them the "*pedal cell-plate*"—the name adopted by me. Similarly, another group of large transparent ciliated cells with yellowish nuclei appears at the postero-ventral end around the anus. This may be called the *anal cell-plate*.

Haddon (1882) writes "In all the Gastropods I have examined, I have found a patch of cilia either around the anus or at that spot where the anus will appear". Kahl (1879) and Meisenheimer (1898) make no mention of these cells in *Planorbis* and *Limax*, respectively. Casteel (1904) observed two such cells in very early stages in *Fiona* and compared them with the anal cells of other Molluscs. Wierzejski (1905) observed them in *Physa*, while Dolsman (1914) has described their origin in *Littorina*.

At the anterior end of the embryo, the ectoderm cells, lying between the median apical cell-plate and the velar lobe on either side, become thickened to form two plate-like structures, one on each side, from which, at a later stage, arise the rudiments of the cerebral ganglia, the tentacles and the eyes. The protoplasm of these cells is thickly granulated and can thus be easily distinguished from the surrounding ectoderm cells. These two ectoderm plates correspond to what has been described as the "*Scheitelplatte*" by Meisenheimer (1898) in *Limax*, Wierzejski (1905) in *Physa*, and others, and as "*Sinnesplatte*" by Schmidt (1891).

In the posterior region of the embryo, just beneath the anterior part of the intestine are found two compact masses of mesenchyme cells,

<sup>1</sup> Both the head-vesicle and the foot merge into each other in *Pila globosa*, as is the case in *Littorina* and *Paludina* in which these regions together have been named as the "Kopffuss" (head-foot) by Dolsman (1914) and Anderson (1924), a name which holds good for these regions in *Pila globosa*.



tapers towards the apex. The pedal cell-plate now consists of two median longitudinal rows of cells (Text-fig. 15a) which extend along the whole of the anterior surface of the foot (Text-fig. 6c).

The stomodaeum has opened into the archenteron (Text-fig. 6c).

The right and left pericardial rudiments have grown towards each other but are still separated by a septum which is many cells in thickness. As development proceeds, they shift towards the right side of the intestine and the primitive stomach.

The rudiments of the right and left kidneys have made their appearance, that of the right kidney being an evagination of the postero-ventral wall of the right pericardium, and that of the left being only a thickening of the left pericardium.

The invagination of the mantle-cavity has deepened, and an evagination taken place from its right inner surface—this is the rudiment of the ureter (Text-fig. 16f). It arises in such a manner that a demarcation between it and the mantle-cavity cannot be made out. It grows obliquely backwards and upwards as a tubular structure, to end blindly against the posterior end of the right kidney.

#### *Stage 4 (Text-fig. 4c).*

The embryo at this stage is about 52 to 56 hours old and about 0.232 mm. in length. It has grown more in length than in breadth, the growth being more marked in the "Kopffuss" (head-foot) region than in the region of the visceral-sac rudiment.

The invagination of the shell-gland at this stage (Text-fig. 6d) is deeper at its anterior than at its posterior end where it is almost flush with the dorsal surface of the embryo. The walls on the sides of this invagination become raised to form a kind of rudimentary ridge round the shell-gland, called the mantle ridge or mantle fold because the edge of the mantle is formed from it.

The foot has become more prominent and tapers antero-posteriorly as in Stage 3. A transverse section passing through the middle of the foot is V-shaped, the two arms of the V representing the two lateral walls of the foot (Text-fig. 24c). The mesenchyme cells of the foot are more closely packed than they are at any other place in the embryo. The embryo at this stage begins to rotate (within the egg-shell) with the help of the cilia on the foot.

The mouth is still situated ventrally. It faces downwards, and leads into the primitive stomach which is broad anteriorly but tapers posteriorly to the beginning of the intestine. The cells lining the primitive stomach become large and vacuolated and thus form the rudiment of the anterior lobe of the digestive gland (Text-fig. 6d). The coelomic cavity between the primitive stomach (digestive-gland) and the body-wall (that is, in the cephalic or head-vesicle region) is small, but that between the intestine and the body-wall (that is, within the region of the visceral-sac rudiment) is large and contains the rudiments of the pericardium and the kidneys. The intestine, as a result of the shifting of the pericardial rudiments towards the right and their gradual increase in size, is pushed towards the left side of the embryo where it opens to the exterior through the anus which has also now shifted towards the left side and lies posteriorly to the left of the invagination of the mantle-cavity.

The mantle-cavity is now much larger and appears as a tubular structure with its external opening in the mid-ventral line. The rudiment of the ureter ascends obliquely on the right side of the embryo and grows backwards and upwards to open at the posterior end of the right kidney.

*Comparison of Stages 1-4 with those of Semper and others:*—On comparing these four stages with those described by Semper (1862) in *Ampullaria (Pila) polita*, I find (from his diagrams in Pl. I), that Semper could not quite correctly orientate the various regions of the embryo. His mistake was probably due to the fact that he did not confirm his observations with the help of sections; and since embryos are almost opaque on account of the presence of a large amount of yolk, one is easily liable to make a mistake in their orientation. Taking, for instance, his fig. 6, Pl. I, comparable to my Stage 1, and bearing in mind the position *b* where according to Semper, the larval heart will develop, I think it would have been correct if *a*, *c* and *d*, instead of representing the foot, the head and the posterior end, as Semper has shown, had denoted the posterior end, the dorsal side and the foot respectively, a view confirmed by the observations of Maria Scott (1934) on *Ampullaria canaliculata*. As regards his fig. 8, Pl. I, its orientation is correct, but Semper could not distinguish the formation of the shell-gland on the postero-dorsal surface of the embryo at this stage. He observed it for the first time, as shown in his fig. 10, Pl. I, *e*, at a much later stage, when the shell-gland area has already shifted down towards the left side. Fernando (1931) and Scott (1934) observed the shell-gland formation in the earlier stages of *Ampullaria gigas* and *A. canaliculata* respectively, and confirm my observations.

In *Pila globosa* the velum forms a continuous circular band around the cephalic (velar) area and it persists as such till a very late stage. According to Scott (1934), the velar cells cease half way along the body and the remaining velar cells protrude in the dorsal region, though they form a continuous band in the earlier stages (see her figs. 9 and 13, Pl. II). Brooks and McGlone (1908) described and sketched the velum as a complete band even at a stage when the gill has started making its appearance (cf. their fig. 7, Pl. I).

#### Stage 5 (Text-figs. 4*d*, *e*).

The embryo at this stage is about 60 hours old and about 0.304 mm. in length. Its dorso-ventral axis is longer than the horizontal axis in the "Kopffuss" region, but it is almost circular in section immediately behind the posterior region of the primitive stomach, as well as in the region covered by the anterior end of the shell-gland, that is, at the junction of the "Kopffuss" and the visceral-sac rudiment.

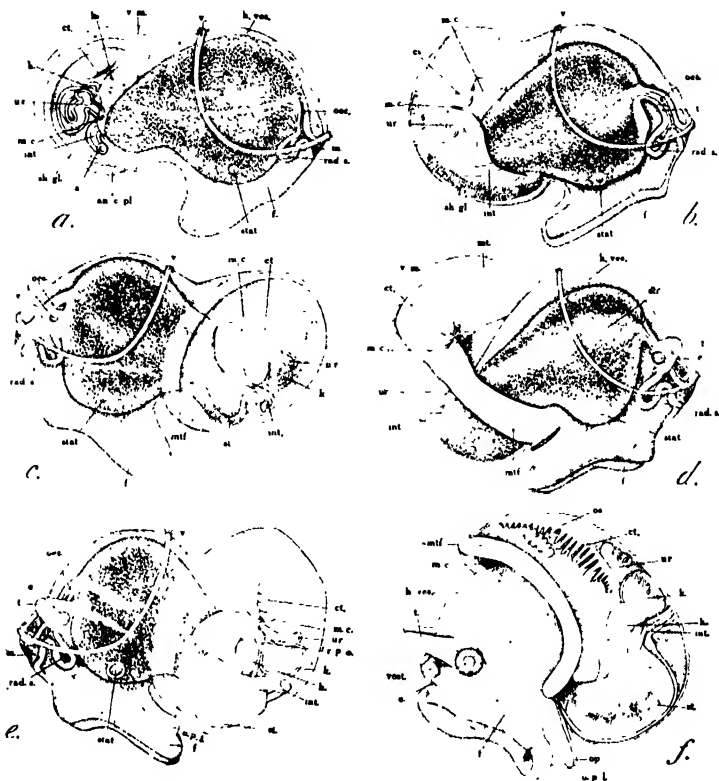
The shell-gland has shifted from its original dorsal position to the left side of the embryo and forms a cup-shaped depression opening widely to the exterior. On account of the invagination growing deeper, the floor of the shell-gland comes to lie anteriorly almost against the postero-dorsal wall of the primitive stomach.

The intestine at first leads straight backwards, but towards the posterior end it curves downwards and opens on the mid-ventral line posterior to and on the left of the outer opening of the mantle-cavity.

The pericardium is now a single, fairly large, sac-like structure situated on the right side of the junction of the primitive stomach and the intestine, the septum between the right and the left pericardial cavity having disappeared.

With the shifting of the shell-gland to the left side, the opening of the mantle-cavity is shifted to the right of its former mid-ventral position. The rudiment of the right ureter has increased in length and leads backwards along the right side, and then upwards to open into the posterior end of the right kidney. This tubular rudiment which cannot yet be differentiated easily from the mantle-cavity, on account of the uniform character of the lumen in both, develops subsequently into the so-called anterior kidney (=ureter) of the adult.

The rudiment of the right kidney has already become a distinct structure and encloses a cavity which communicates widely with the



TEXT-FIG. 5. Figures of whole embryos showing Stages 8-12.

a. Right view of an embryo in Stage 8:  $\times 64$ ; b. Right view of an embryo in Stage 10:  $\times 59$ ; c. Left view of an embryo in Stage 10:  $\times 66$ ; d. Right view of an embryo in Stage 11:  $\times 52$ ; e. Left view of an embryo in Stage 11:  $\times 50$ ; f. Left view of an embryo in Stage 12:  $\times 34$ .

pericardial cavity from which it has evaginated. The kidney can be easily distinguished by its colour which is darker than that of the pericardium, and by the uniform thickness of its walls.

Judging from Semper's figs. 9 and 10, Pl. I, my Stage 5 is approximately the same as his 'third' stage; while his orientation of fig. 10 is correct, fig. 9 is again wrongly orientated. In order that the figure be correctly orientated, letters a, c and d should represent the posterior end, the dorsal side and the foot respectively of the embryo. Only in this way will it show proper resemblance to fig. 10; a would then represent the buccal cavity, instead of an aperture related to respiratory organs<sup>1</sup>. Semper is wrong about the opening of the respiratory organs, as, in fact, the respiratory organs in *Pila* appear much later and there can be no aperture at this stage (cf. Brooks and McGlone, 1908, Fernando, 1931, and Scott, 1934).

Up to this stage Semper does not make any mention of the formation of either the pericardium or the mantle-cavity or the kidneys which, as is quite evident from my preceding account, are already in an advanced stage of development.

<sup>1</sup> It was at this stage that Semper first noticed the appearance of the shell-gland, which had already shifted to the left side of the embryo.

*Stage 6 (Text-figs. 4f, g).*

The embryo at this stage is about 62 to 68 hours old and 0.392 mm. in length. Considerable increase has taken place in the size of the embryo, specially in the region of the visceral-sac rudiment. The yellow colour of the embryo present in the preceding stages is now restricted to the alimentary canal, with the result that the embryo becomes slightly transparent. Growth has taken place chiefly in the dorso-ventral direction, as can very well be seen by examining the embryo from the side. Dorso-ventrally the embryo is still broader in the anterior or "Kopffuss" region than in the posterior or visceral-sac rudiment region.

A transverse section passing through the "Kopffuss" shows that the convexity of the side walls has decreased and the part lying dorsal to the velum appears horse-shoe shaped, while the part below the velum gradually tapers downwards and inwards to meet at a conical point thus forming the V-shaped foot. A section passing immediately behind this region shows an oval outline, the rounded appearance of the preceding stage being lost. A transverse section passing through the middle of the visceral-sac rudiment shows a convexity of the body-wall on the right side, while there is a concavity on the left side due to the shell-gland invagination.

So far, the longitudinal axis of the "Kopffuss" and the visceral-sac rudiment is in a straight line.

The shell-gland develops a cuticle, the rudiment of the shell, surrounded by a raised ridge of the mantle-fold (Text-fig. 4f) occupying the greater part of the left surface of the visceral-sac rudiment. A deep groove, deeper anteriorly than posteriorly, runs all round the shell-gland just beneath the mantle-fold: this is the mantle groove. Though the extreme anterior end of the shell-gland is still deeply invaginated and lies against the postero-dorsal wall of the primitive stomach (Text-fig. 7b), evagination has already set in a little behind it, and towards the posterior part of the shell-gland this eversion or evagination is complete, and a flat surface of uniform thickness is obtained extending right up to the posterior end of the embryo.

The foot is now, for the first time, marked off anteriorly from the head-vesicle of the embryo. In a transverse section, the side-walls of the foot lying just beneath the velum are seen to be pressed inwards to become almost parallel to each other, after which they bend at an approximate angle of  $45^\circ$  and pass downwards and inwards to meet in the mid-ventral line. The anterior surface of the conical foot begins to flatten and marks the beginning of the formation of the flat creeping sole of the foot, the pedal cell-plate now forming a ridge on the mid-ventral surface of the foot. The sole is restricted to the anterior surface of the foot, the part lying behind appearing almost similar to that in the preceding stage.

In the stomodaeum, just behind the mouth, the floor of the fore-gut sends out a ventral outpushing, the rudiment of the radular sac (Text-fig. 7b), which marks the posterior boundary of the buccal cavity. The part of the gut between this ventral outpushing and the primitive stomach is the oesophagus.

The primitive stomach (Text-fig. 7b) has grown considerably in size and has a spacious lumen, so that the cavity lying between the primitive

stomach and the body-wall is very much reduced. This stomach is broad anteriorly but narrows gradually towards its posterior end, where it projects into the antero-ventral part of the visceral-sac rudiment, and bends slightly ventrally to open into the intestine. The cells of the wall of the primitive stomach (the rudiment of the digestive-gland) have grown much longer in size and have also become more vacuolated.

The darkly staining postero-ventral part of the primitive stomach which now lies within the visceral-sac rudiment and appears cone-like in a lateral view, becomes differentiated from the rest of the primitive stomach; this is the first appearance of the true or adult stomach which lies towards the right ventro-lateral side. In transverse (Text-fig. 15b) and sagittal sections (Text-fig. 7b), its wall is seen to be composed of regularly arranged, thickly granular, columnar cells.

The intestine leads backwards and, after making a sharp bend downwards of about 90°, opens to the exterior on the mid-ventral line (Text-fig. 7b), a little behind and to the left of the external opening of the mantle-cavity (Text-figs. 4f, g). The anus is situated at the anterior end of a group of large ciliated cells (anal cell-plate) which extends right up to the posterior end of the embryo.

The thin-walled, sac-like pericardium, which is elongated dorso-ventrally, is situated midway on the right side of the embryo, lying antero-dorsally to the junction of the intestine and the primitive stomach (Text-fig. 4f). Anteriorly it occupies nearly the whole of the space between the primitive-stomach and the body-wall. The heart, which is quite prominent at this stage, is situated in the pericardium near its postero-dorsal wall.

The mantle-cavity is marked off internally from the ureter by the appearance of a constriction in its inner wall.

The right kidney still occupies a postero-ventral position and, therefore, the reno-pericardial aperture (*i.e.*, the aperture through which the kidney and the pericardium communicate with each other) is also ventral in position.

At this stage a part of the integument lying between the foot and the anus just below the intestine, with its underlying mesenchyme cells, begins to pulsate. This is the embryonic or larval heart.<sup>1</sup> But whether it is at this stage that the larval heart pulsates for the first time or whether it was pulsating earlier I cannot definitely say, as the earlier stages are opaque and make observation difficult.

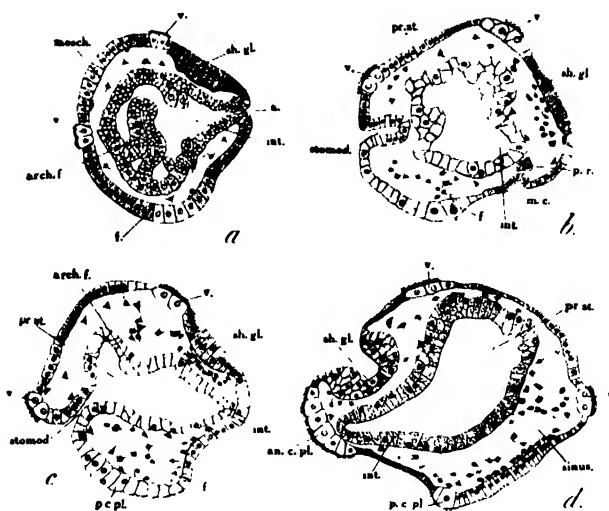
#### *Stage 7 (Text-fig. 4h).*

The embryo at this stage is about 72 to 78 hours old and about 0.616 mm. in length. It is of a dull white colour and more or less transparent, so that the outlines of the various organs can be clearly seen. The rudiment of the visceral-sac has grown more in length and height than any other part of the embryo. The rotation of the organs towards the right side seen in the earlier stages as having brought about the

<sup>1</sup> Semper (1862) and Scott (1934) observed it in a stage almost the same as that of mine (Text-figs. 4f, g), as is shown in figs. 12 and 13, Pl. II of the former author, and fig. 17, Pl. III of the latter.



asymmetry of the embryo, becomes well-marked now. The rotation being from left to right, *Pila* exhibits dextral torsion.



TEXT-FIG. 6. Sections of embryos in Stages 1-4, showing early stages in the development of the archenteric folds, the pericardial rudiment, the stomodaeum and the shell-gland.

*a.* Sagittal section of an embryo in Stage 1, passing through the anus and showing the archenteric folds:  $\times 332$ ; *b.* Sagittal section of an embryo in Stage 2, passing through the rudiment of the mantle-cavity and the inner end of the right pericardial rudiment:  $\times 246$ ; *c.* Sagittal section of an embryo in Stage 3, showing the opening of the stomodaeum into the primitive stomach:  $\times 246$ ; *d.* Sagittal section of an embryo in Stage 4, passing through the invaginated shell-gland:  $\times 204$ .

The shell-gland at its anterior end is now almost completely flattened out and the shell cuticle forms a thin membrane over it. On account of the transparency of the embryo, the pulsations of the definitive heart are seen for the first time. These pulsations, unlike the irregular beats of the larval heart, are rhythmical. The foot begins to show movements, which are well marked towards its posterior end. When a contraction occurs, the posterior part of the foot is pulled upwards and almost touches the antero-ventral surface of the visceral-sac rudiment.

The radular sac has become well-marked. The anus no longer lies on the mid-ventral line but has shifted to the right, although it still maintains its original relation to the opening of the mantle-cavity, and lies behind and to the left of the external opening of the mantle-cavity.

The pericardium now comes to lie dorsally to the intestine, and the pulsating heart lies within it. If the embryo is taken out of the egg-shell, separated from the surrounding albumen and placed in normal saline solution, the pulsations can be seen for a few minutes, after which the rate of pulsation gradually decreases till it finally ceases.

The opening of the mantle-cavity has, as a result of further torsion, been displaced upwards and comes to lie near the middle of the right side.

The right kidney, though retaining its connection with the pericardium through the postero-ventral reno-pericardial aperture, begins to shift towards the dorsal side (Text-fig. 8a).

*Stage 8 (Text-fig. 5a).*

The embryo at this stage is about  $3\frac{1}{2}$  days old and 0.736 mm. in length. The dextral torsion has become still more prominent, the left postero-ventral part of the visceral-sac rudiment having rotated towards the right and showing a tendency to grow upwards and forwards. The visceral-sac rudiment, as a whole, has grown as large as the "Kopffuss" and appears now as a saucer-shaped structure with a shallow depression on its right side. Its longitudinal axis, as a result of torsion, lies at an angle of about  $45^\circ$  to that of the "Kopffuss". On its dorsal side, just behind the velar cells, appears a depression which marks the anterior boundary of the visceral-sac. In a lateral view the embryo looks like two incomplete spheres joined end to end. The visceral-sac rudiment gradually diminishes in thickness antero-posteriorly. On examining a series of transverse sections of the visceral-sac rudiment from the anterior to the posterior end, it is observed that in the region of the stomach the body-wall of the right side bulges outwards, while it curves in dorsally in front of the pericardium. The left body-wall, however, is almost flat, consisting of the shell-gland bounded by the mantle folds. A transverse section passing through the pericardium shows that the flattened part of the shell-gland has started bulging out, and that the part of the embryo lying dorsally to the pericardium is laterally compressed and is narrower than the ventral part. It is the rudiment of the mantle. The bulging on the left side, where the cells of the shell-gland have flattened, lies against the posterior region of the stomach and is the rudiment of the visceral hump. The peripheral part of the everted shell-gland represents the shell-gland of the adult. The shell-gland is still circular in outline and covers the entire left side of the visceral-sac.

In sections, as well as in whole mounts (Text-fig. 5a), the foot is seen to have developed ventrally a flat, creeping sole, broader anteriorly than posteriorly. Anteriorly, the lateral walls of the foot run parallel to each other and at right angles to the flat sole, and the foot is marked off from the head-vesicle as its anterior wall forms a curve backwards and downwards to continue into its ventral wall. At about its middle, the side walls of the foot still imperceptibly merge into those of the head-vesicle. The height of the foot is greatest about the middle of its length but diminishes anteriorly. Viewed from the ventral side, the anterior border of the foot appears rounded while the lateral walls look curved slightly inwards. The postero-dorsal wall of the foot forms an acute angle with the longitudinal axis of the embryo.

The radular sac evagination of the floor of the fore-gut has sunk deep, and is directed downwards and backwards. The stomach no longer lies in the mid-ventral line but has shifted towards the left side, and it is here that the rudiment of the visceral hump lies against it. The part of the primitive stomach from which the adult stomach differentiates moves to the right-dorsal side, but the two remain communicating widely with each other. The bulging on the right side lies opposite to it. The

intestine has elongated considerably and runs backwards and downwards and then bends forwards to open on the right side almost in the same vertical plane as that of the external opening of the mantle-cavity, but slightly ventral to it. The anus which lies at the anterior end of the anal cell-plate is placed to the right of the dorso-ventral axis of the visceral-sac rudiment (Text-fig. 23a).

The mesenchymatous tissue within the body is very much concentrated in the foot.

The pericardium now lies completely on the dorsal side of the gastro-intestinal junction.

The tubular mantle-cavity is constricted off from the ureter, which runs postero-dorsally along the body-wall of the right side of the embryo, and then bends forwards to open into the kidney.

The kidney lies against the posterior wall of the pericardium and is now directed dorsally.

A depression appears on either side of the body-wall, posteriorly to the velum at about the middle length of the "Kopffuss", where the foot merges into the head-vesicle. This is the rudiment of the statocyst.

A part of the right wall of the visceral-sac rudiment situated dorsocally to the level of the pericardium becomes thickened to form a common ridge-like area from which the rudiments of the gill, the osphradium, and the lung are formed (Text-figs. 5a and 23a).

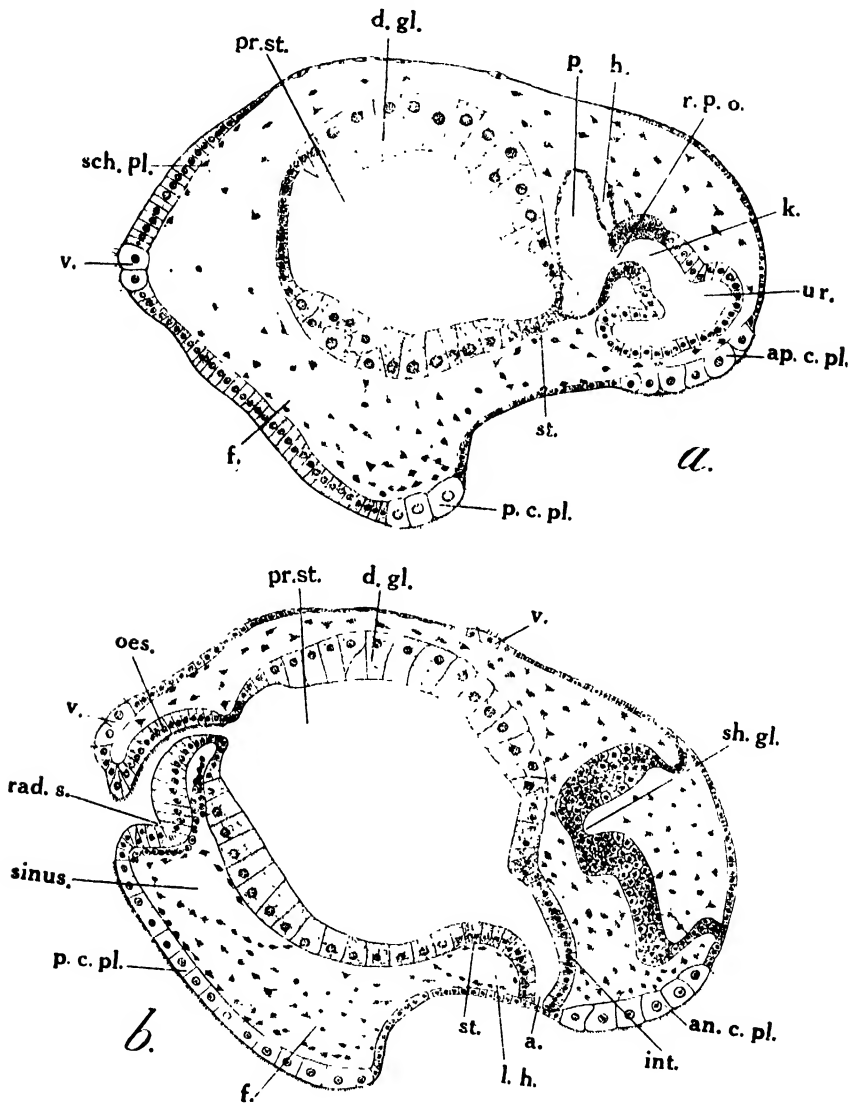
#### *Stage 9 (Text-fig 8b).*

The embryo at this stage is about 4 days old and 0.756 mm. in length. The shell-gland, along with the shell cuticle, has increased in size, and has grown further towards the ventral side as a result of further torsion of the visceral-sac rudiment. The bulge of the rudimentary visceral hump has increased in size and now extends right up to the posterior end, the direction of the bulge being downwards and outwards. Similarly, the bulge on the right side has also become well developed and has grown upwards in the posterior region behind the external opening of the mantle-cavity. The concavity of the visceral-sac on its right side has deepened posteriorly and appears bowl-shaped. The rudiments of the gill, the osphradium, and the lung are already formed from the thickened ridge-like area which bounds the concavity on the right side. Of these, the first two develop as outpushings, while the last forms as an inpushing between them.

On the postero-dorsal surface of the foot, a thin cuticular membrane has already been secreted by the ectodermal cells of that region; this forms the rudiment of the operculum.

The postero-dorsal part of the primitive stomach lying opposite the adult stomach-rudiment grows dorso-laterally on the right side, and forms the abovementioned bulge on that side. This outgrowth, which communicates widely both with the anterior rudiment of the digestive-gland and the true stomach, is the second and posterior rudiment of the digestive-gland, which lies completely within the visceral-sac rudiment. Subsequently, it develops into the digestive-gland of the adult, the anterior rudiment having been absorbed at a later stage.

A part of the pericardium has already shifted downwards to the left side of the intestine. As the pericardium is thus displaced, the reno-



TEXT-FIG. 7. Early development of the kidney, pericardium, ureter and radula sac.

*a.* Reconstruction of a few sagittal sections of the right side of an embryo in Stage 6, showing the opening of the right kidney into the pericardium and the ureter:  $\times 195$ ;  
*b.* Reconstruction of a few sections of the same embryo as in (*a.*), showing the evagination of the radular sac:  $\times 195$ .

pericardial aperture, which was ventral in position, now comes to lie in a postero-dorsal position. The kidney has grown in size and is now a sac-like structure situated posterior to, and a little to the right of the pericardium.

The mantle-cavity is now large and spacious.

The statocysts are now in the form of deep invaginations but still open to the exterior.

*Stage 10 (Text-figs. 5b and 9).*

The embryo at this stage is about  $4\frac{1}{2}$  to 5 days old and 0.776 mm. in length. The torsion is complete. The postero-ventral part of the visceral-sac has moved on to the right side, and has come to lie upwards and forwards, its former longitudinal axis now lying nearly at right angles to that of the "Kopffuss" (cf. Text-figs. 19a, b; 21d; and 24o). The visceral hump is now directed downwards, outwards and backwards. The concavity on its right side, seen facing outwards in the preceding stage, now lies on the dorsal side and faces antero-dorsally. The lower (ventral) part of the mantle fold, lying on the left side in the earlier stages, has now come to lie on the right, and is nearly at right angles to its former position (Text-figs. 21d and 24o).

The foot has developed further; in its anterior part the side walls have curved in towards each other to join below at the base of the head-vesicle (Text-fig. 24j), which at its extreme antero-dorsal end is now developing into the characteristic head of the adult. The ventral surface of the foot is quite flat and the two longitudinal rows of cells of the pedal cell-plate are still present along the entire length of the foot.

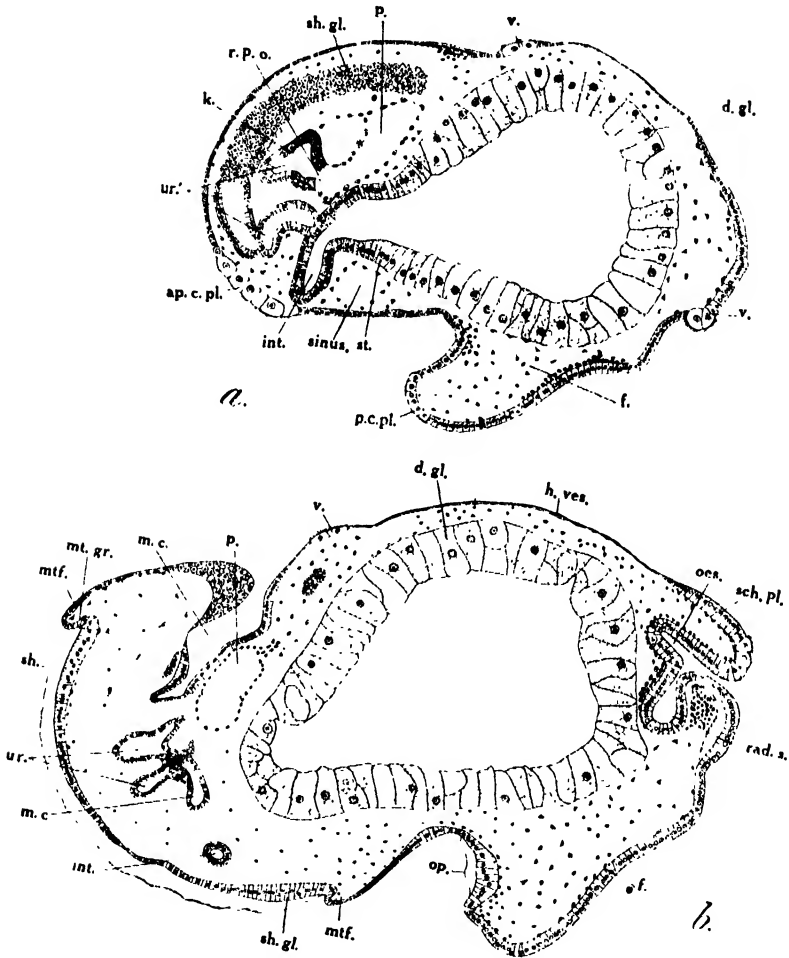
On each of the dorso-lateral walls of the oesophagus, opposite the opening of the radular sac, arises an outpushing; these two outpushings are the rudiments of the salivary glands, and arise simultaneously with the oesophageal pouches, which are similar outpushings situated a little anteriorly. In the mid-gut, the second rudiment of the digestive-gland enlarges within the visceral-sac, so that the two appear as diagonally opposed bulgings. The intestine elongates as a result of torsion. Arising from the left postero-dorsal side of the stomach, it runs downwards and backwards and makes a curve to come forward and open anteriorly, for the first time, at the extreme right end into the mantle-cavity, at one end of the anal cell-plate.

The deep and spacious mantle-cavity now occupies its final dorsal position (Text-fig. 21d). Posteriorly, by the upward and forward rotation of the postero-ventral part of the embryo, the right and left mantle lobes approach each other, at a later stage, to meet in the centre and form the roof of the cavity.

The ureter (or anterior kidney) has elongated a great deal, but still retains its simple tubular character. A part of it now comes to lie anteriorly to the kidney, which in turn lies posteriorly to and to the right of the pericardium, and forms a wide chamber. The reno-pericardial aperture opens on the postero-dorsal wall of the pericardium which has also grown considerably in size.

The statocysts no longer open to the exterior but form closed vesicles beneath the side walls of the foot, having shifted downwards and inwards, away from their places of origin. They appear circular or oval in a lateral view of the embryo.

The rudiments of the gill, the osphradium and the lung are now well differentiated. I have been able to count rudiments of five to six gill-



TEXT-FIG 8. Embryos in Stages 7 and 9.

*a.* Sagittal section, passing through the right side of an embryo in Stage 7:  $\times 134$ ;  
*b.* Sagittal section of an embryo in Stage 9:  $\times 114$ .

filaments projecting into the mantle-cavity from the inner wall of the mantle on the left side (Text-fig. 19*b*).

Fernando (1931) failed to observe the formation of the gill at this stage in *Ampul-  
 laria (Pila) gigas*. Brooks and McGlone (1908) described the gill in *A. depressa* at a  
 stage which can be readily compared with my Stage 9 (see their fig. 7, Pl. I). If we  
 examine fig. 21, Pl. III of Semper (1862) in case of *A. polita*, it will be noticed that his  
 stage is just a little more advanced than my Stage 10. He has shown the gill in an  
 advanced state of development, in which the gill-filaments have already developed  
 cavities within them (see his fig. 18). Scott (1934) mentions the formation of the gill  
 at a stage (see her fig. 23, Pl. V) corresponding to that of Semper (fig. 21, Pl. III) in  
 which the shell is still definitively left in position and the lamellae of the gill are deve-  
 loping towards the posterior part of the visceral-sac, taking the form of folds on the wall  
 of the mantle. On making these comparisons I believe that Fernando must have failed  
 to observe the formation of the gill in the earliest stages of its development.

The "head plates" (=the "Scheitelplatte" of some of the German authors, and the "Sinnesplatte" of Schmidt), which lie within the velar area and form the side walls of the anterior end of the head-vesicle (p. ), get flattened and lie parallel to each other (Text-figs. 24j and 28b). A depression appears in the middle of each plate, while its antero-dorsal region is pushed out as a small protuberance. These depressions are the rudiments of the eyes, while the protuberances are the rudiments of the tentacles (Text-fig. 28b), the two rudiments appearing simultaneously in *Pila globosa*.

Semper (1862) did not observe the formation of either the tentacle, or the eye, at this stage in *A. polita*. He mentions their appearance at a much later stage (see his figs. 24 and 25, Pl. IV) when the embryo is about to hatch. He mentions that the rudiments of the eye and tentacle are absent at Stage 10. Moreover, he describes the appearance of the eyes to be earlier than that of the tentacles. Brooks and McGlone (1908) do not make any mention of the appearance of the eye or the tentacle rudiments at the stage at which the gill appears. Fernando (1931) has also made no mention of their formation. Scott (1934) describes the formation of the tentacles at approximately the same stage as mine. She makes no mention, however, of the eyes at this stage, but describes them at a later stage (cf. her fig. 24, Pl. V).

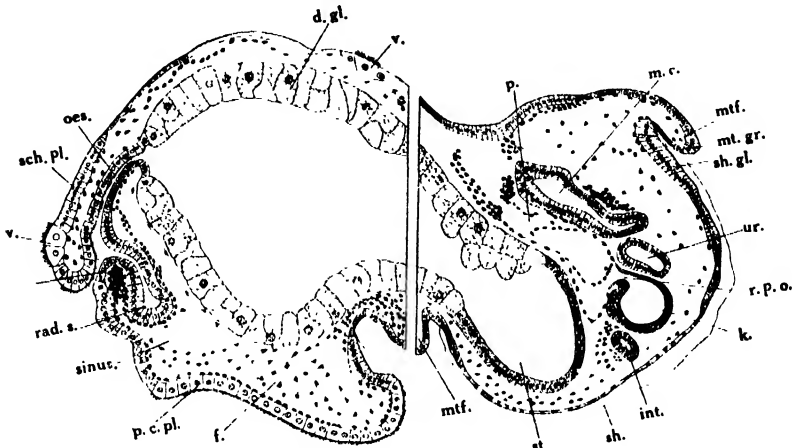
#### Stage 11 (Text-figs. 5d, e, and 10).

The embryo at this stage is about  $5\frac{1}{2}$  to  $6\frac{1}{2}$  days old and 0.960 mm. in length, and looks perfectly snail-like in appearance. The visceral-sac has become dome-shaped as a result of rapid growth, and now lies much forwards, the apex of the dome being directed backwards and downwards. The entire surface of the visceral-sac is covered over by the thin transparent shell which forms a cap over the dome. The thick mantle fold is strongly developed and is directed backwards, with the mantle groove running beneath it (Text-fig. 10). A transverse section of the visceral-sac passing through the anus and the osphradium shows that the dorso-ventral axis of the embryo, in this region, is shorter than its horizontal axis; in other words, the breadth of the embryo, in this region, is greater than its height. This relation is reversed as we go towards the posterior end, i.e., in the region of the kidney.

The postero-dorsal surface of the foot has become thickened and raised to form beneath the operculum a platform, the operculigenous lobe.

The radula begins to be differentiated within the radular sac, which has grown large in size and is directed downwards and backwards. A constriction appears at about the junction of the head-vesicle with the visceral-sac, due to the deepening of the mantle-cavity on the right side (Text-fig. 25e). The anterior part of the digestive-gland lying within the head-vesicle is still large, but hereafter it shows indications of diminution in size. The oesophagus has grown in length and opens into the primitive stomach. The posterior part of the digestive-gland has grown in dimensions and occupies the greater part of ventral half of the visceral-sac. By a rapid growth and expansion of this posterior part, the rest of the organs are displaced towards the latero-dorsal side. The intestine, arising from the left postero-dorsal side of the stomach, extends backwards and, bending round the posterior end of the digestive-gland, turns forwards to run obliquely upwards and opens anteriorly through the anus. The anus is now situated at the extreme right end of the mantle cavity, lying postero-ventrally to the anal cell-plate which is still present.

The pericardium, with the heart, occupies a very large space on the left side of the embryo, and is covered by the epithelium of the visceral-sac which, in turn, is protected by the shell.



TEXT-FIG 9. Diagram showing two sections of an embryo in Stage 10. The left half is a median longitudinal section, while the right half passes on the left of the median line :  $\times 114$ .

The kidney has also grown into a spacious chamber ; it is no longer a simple sac but has finger-like folds projecting into its cavity from its walls. It is situated posteriorly to and on the right side of the pericardium and can be readily recognised from the latter by its darker colour. The ureter (=anterior kidney) lies to the right of and dorsally to the kidney, while a part of it lies above the mantle-cavity on its extreme right. The dorsal wall of the ureter is already produced into folds. The kidney proper lies posteriorly to the ureter on its left side.

The spacious mantle-cavity has already passed over to the left side of the embryo, and is bounded ventrally by the body-wall covering the stomach, digestive-gland, and the pericardium, while laterally as well as dorsally it is bounded by the thick mantle itself (Text-fig. 23c). The gill lies obliquely inside the mantle-cavity and extends from its left posterior end to its right anterior end. The osphradium is seen suspended from the wall of the mantle towards the left anterior end of the mantle-cavity.

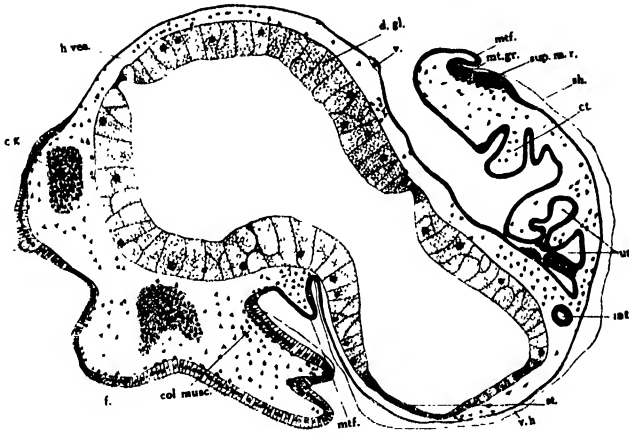
The eyes now form closed vesicles, but no further differentiation of their parts has yet taken place. They lie on the outer side of the bases of the tentacles which form peg-like conical projections, broad at the base and tapering towards their distal end. They are directed outwards, forwards and upwards. The region of the head-vesicle lying between and anterior to the eyes and tentacles is distinctly marked off from the region lying posteriorly to it. It has become broader but shorter in height, a differentiation leading towards the formation of the head proper.

#### *Stage 12 (Text-figs. 5f and 11).*

The embryo in this stage is about  $7\frac{1}{2}$  to  $8\frac{1}{2}$  days old and 1.36 mm. in length. The visceral-sac, covered all over by the shell, gradually travels forwards towards the anterior end, and encloses the head-vesicle of the



embryo. The mantle surrounds the head-vesicle like a cloak, and the shell follows the progress of the mantle and thus reaches its adult shape and position. On account of the deposition of lime salts, the shell loses its transparency and becomes gradually opaque. The visceral hump has gone through one complete spiral on the right side (dextral). A pair of cartilages have already formed anteriorly to the radular sac.



TEXT-FIG. 10. Sagittal section of an embryo in Stage 11, passing through the opening of the ureter into the mantle cavity:  $\times 124$ .

The anterior lobe of the digestive-gland lying within the head-vesicle is now very much reduced and appears as a tubular structure at the anterior end of which opens the oesophagus (Text-fig. 11). As development proceeds, this lobe of the digestive-gland is reduced still further, till it completely recedes from the head-vesicle. The posterior lobe of the digestive-gland, on the other hand, grows in size, becomes spherical and fills a very large part of the visceral-sac.

The oesophagus is very much elongated and, on account of the complete recession of the anterior lobe of the digestive-gland, traverses the whole length of the head-vesicle to enter the left side of the stomach within the visceral-sac (Text-fig. 26*g*). This can be easily understood by a comparison of Text-figs. 11 and 26*a, b, g*. In Text-fig. 11 the anterior rudiment of the digestive-gland is present in the form of a tubular structure, but in Text-fig. 26*g* it has completely disappeared to give place to the oesophagus.

The operculum is now well formed and the columellar muscle is strongly developed (Text-fig. 11). The foot has now assumed its final shape.

The eyes at this stage are well formed, each having developed a lens and a retina (Text-fig. 28*c*). They are raised on small elevations, the rudiments of the ommatophores. The tentacles have grown in length and, instead of being conical or peg-like, are now elongated and taper towards their apices and show their characteristic movements. The head region has become further differentiated with the formation of the rudiment of the labial palps arising at the extreme anterior end of the head.

No new structures appear after this stage and the embryo now resembles the adult in all respects except in size. The apical cell-plate, the pedal cell-plate and the anal cell-plate have all disappeared, and so also has the velum.

The shell has now all the characteristics of the adult shell and is of a dull yellowish colour. The outer wall of the mantle, lying a short distance behind the edge of the mantle has also become pigmented.

The embryo is now capable of being fully retracted within the shell. The operculum can completely close the mouth of the shell holding the retracted animal. With further development, the shell, along with the visceral mass, develops a second whorl. The embryo, which is now a miniature of the adult, grows in size until it hatches out of the egg-shell to lead a free existence.

## IX.—THE DEVELOPMENT OF THE ORGAN-SYSTEMS.

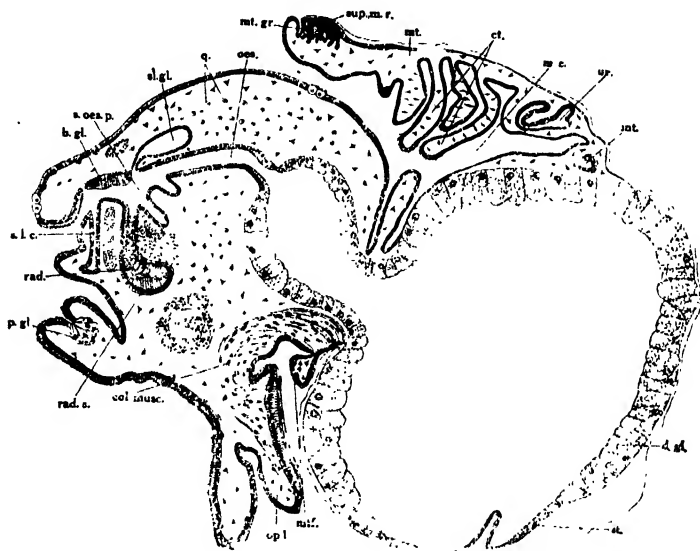
### A. *The Alimentary Canal.*

It has already been described in Section VII that the alimentary canal is laid down in the gastrula as the archenteron, that the original blastopore forms the anus, and that the stomodaeum is a new ectodermal invagination.

The further development of the alimentary canal may now be described. The canal consists of two parts, an ectodermal and an endodermal, which are described below:—

1. The ectodermal fore-gut or stomodaeum, consisting of the radular sac, the salivary glands, and the oesophageal pouches, are all differentiated from the stomodaeum.

2. The endodermal part or mesenteron, which is itself further divisible into two parts: (i) the stomach with its associated digestive-gland and (ii) the intestine.



TEXT-FIG 11. Reconstruction of a few sagittal sections of an embryo in Stage 12;  $\times 80$ ,

*The Stomodaeum.*

The rudiment of the stomodaeum is first recognised in an embryo slightly younger than Stage 1 (Text-fig. 4a). A few ectodermal cells of the body-wall, lying immediately behind and ventrally to the velum, become tall and columnar, and form a thick plate of cylindrical cells. They can also be distinguished from the adjacent epithelial cells by their larger size, and by their capacity to take up a deep stain. The cells of this plate divide rapidly and multiply and are pushed inwards to form the stomodaeal invagination (Text-fig. 4a). With further growth, this invagination deepens (Text-figs. 4b and 6b) and grows inwards and posteriorly to fuse with the anterior wall of the archenteron, and opens into the latter (*cf.* Stage 3, Text-fig. 6c). Thus, the digestive tract at this stage of development communicates with the outside at both ends, the anterior end forming the mouth and the posterior forming the anus (Text-fig. 4c), the whole of the rudimentary alimentary canal lying in the median plane of the embryo. The mouth is oval in form and faces downwards; it leads into the stomodaeal invagination which bends slightly dorsolwards to open into the archenteron. The limits of the stomodaeum and the archenteron can be easily distinguished by their staining reactions, the yolky endoderm cells do not take as deep a stain as do the stomodaeal cells. Further, the stomodaeal cells are ciliated, the cilia helping to carry the albumen surrounding the embryo through the stomodaeum into the archenteric cavity.

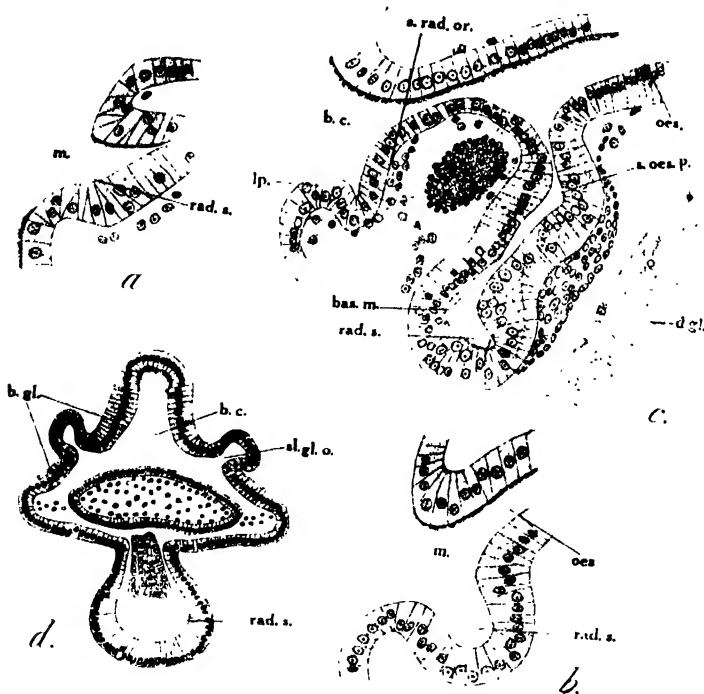
In the earlier stages, the stomodaeum opens into the ventral side (Text-fig. 6c) of the archenteron, but gradually this opening of the foregut first comes to lie at about the middle of the anterior surface of the primitive stomach (Text-fig. 4d), and finally at its antero-dorsal end (Text-figs. 5a, b, d).

The stomodaeum, in its earliest stages, is a simple tubular structure consisting of cells of equal size and similar shape (Text-fig. 6b, c). But in about Stage 6 the cells of its floor, lying a little behind the triangular mouth (now facing forward), form a thick plate of tall cylindrical cells (Text-fig. 12a), and the lumen of the stomodaeum, in the region of this plate as well as anterior to it, grows wider than it is behind. I call this thickened ectodermal plate the rudiment of the radular sac (Text-fig. 12a), since it immediately precedes the radular sac depression, which forms at this place in the next stage (Text-figs. 4f, g, and 7b). Just at this time a few scattered mesenchyme cells aggregate together to form a kind of "string of beads" all along the ventral surface of the stomodaeal wall, extending from the mouth to a little behind the radular sac thickening (Text-fig. 7b). These cells form the early representatives of the radular cartilages and their muscles.

The radular sac depression deepens and forms an evagination of the floor, directed downward and slightly backward (Text-fig. 7b). This evagination divides the stomodaeum at this stage into two parts—the part lying anterior to it represents the buccal or pharyngeal region, while the posterior part forms the oesophagus. In its earliest stages, the lumen of this evagination (radular-sac rudiment), as seen in a lateral view, appears wider anteriorly, *i.e.*, at the place of its opening into the buccal cavity, but narrower postero-ventrally, *i.e.*, towards its blind end

(Text-figs. 4*b*, *h* ; and 7*b*). As development proceeds, the sac grows deeper and its lumen widens, its opening into the buccal cavity being directed antero-dorsally (Text-fig. 12*b*). The posterior wall of the radular sac is continuous with the ventral wall of the oesophagus which bends sharply upwards and then obliquely backwards to open into the primitive stomach.

Along with the increase in length of the whole of the fore-gut, the radular sac also grows in size. In the roof of the fore-gut the outer parts of the cells become hyaline, while their inner ciliated halves retain their original character (Text-fig. 8*b*). The cells forming the floor show no such change. The radular sac increases in length and curves backwards in such a way that the posterior wall of the sac now becomes the roof while the anterior wall becomes the floor of the sac. There is also a dorso-ventral flattening beginning from the opening of the radular sac into the buccal cavity, which consequently becomes narrow (Text-figs. 5*a* and 8*b*). The floor of the buccal cavity, lying immediately in front of the opening of the radular sac, becomes slightly raised upwards, and the mesenchyme cells (Text-figs. 5*a* and 8*b*) beneath this raised epithelium increase in number and form a compact mass. This mass of cells, together with the raised buccal floor, form the beginning of



TEXT-FIG. 12. Stages in the development of the radular sac and the salivary glands.

*a*. Sagittal section through the radular sac rudiment of an embryo in Stage 6:  $\times 390$ ; *b*. Sagittal section passing through the radular sac of an embryo in Stage 7:  $\times 390$ ; (*c*). Sagittal section of an embryo in Stage 11, passing through the radular sac and the fore-gut; *d*. Transverse section of the buccal cavity of an embryo in Stage 11, passing through the opening of the salivary glands:  $\times 228$ .

the odontophoral mass or tongue-mass. This compact mass of mesenchyme cells gives rise to the so-called "cartilages" and their associated muscles.

The dorso-ventral flattening of the radular sac continues except at its extreme posterior end, which becomes knob-like, giving the whole structure a club-shaped appearance, the posterior end forming the knob, and the anterior part forming the body of the club (Text-fig. 9). Due to this flattening, the lumen of the sac in transverse sections loses its circular character and appears half-moon shaped (Text-fig. 24j). In the knob-like posterior end, however, the lumen remains wide.

The odontophoral mass develops further, and a transverse section passing through this region shows that, on account of the growth of the odontophore into the floor of the buccal cavity, the latter now consists of two narrow laterally-compressed side-alleys with the odontophoral mass situated in the middle (Text-fig. 24j). Thus, while the buccal cavity in front of the odontophoral region has a wide lumen, it forms two narrow chinks in the region of the odontophore, and then widens out into a triangular cavity just above the opening of the radular sac in front of the oesophagus (Text-fig. 25f).

Vacuoles make their appearance in the cells composing the dorso-lateral walls of the oesophagus, which is ciliated all along its length up to its opening into the primitive stomach.

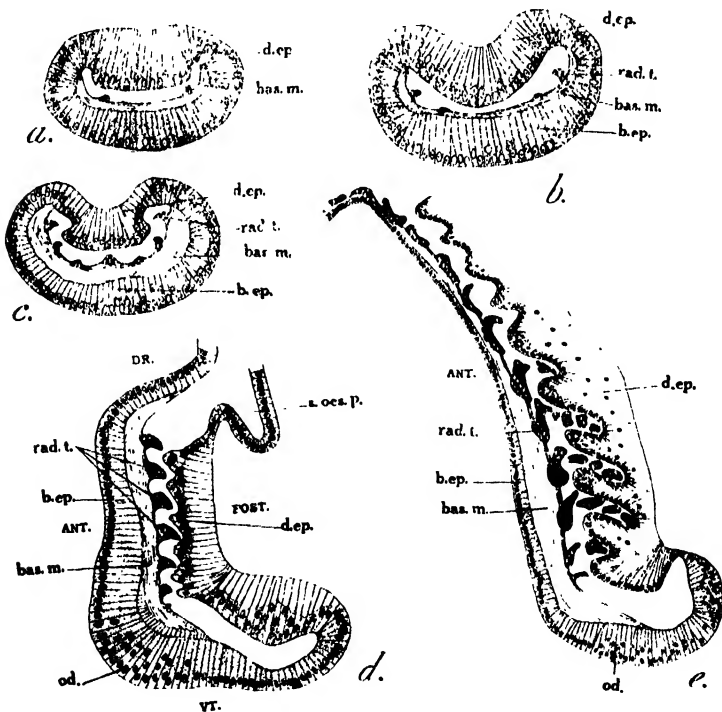
By the time torsion is complete (*cf.* Stage 10), the margins of the slit-like mouth have thickened to form "secondary lips" (Text-fig. 12c), and the buccal cavity has differentiated into an anterior vestibule and a posterior odontophoral region extending up to the oesophagus. The vestibule is lined dorso-laterally with a single row of half-hyaline ciliated cells. The arched roof of the odontophore extending anteriorly makes an abrupt bend downwards to be continued into the floor of the vestibule. The area where the downward bend occurs, forms the rudiment of the sub-radular organ.

The dorso-lateral walls of the buccal cavity above the opening of the radular sac become glandular on each side—these glandular areas form the rudiments of the buccal glands (Text-fig. 12d). At the middle of each gland the buccal wall forms an outpushing, the rudiment of the salivary gland. The openings of these glands into the buccal cavity lie a little anteriorly to the transverse plane of the eye-rudiments, as seen in Text-fig. 28b (Stage 10). The rudiments of the salivary glands develop into simple tubular glands extending posteriorly along the walls of the oesophagus. At the time of their first appearance, the openings of the glands into the buccal cavity are wide, and remain so even when the glands become tubular. Text-fig. 12d is an obliquely transverse section of a later stage (Stage 11) passing through the openings of the salivary glands into the buccal cavity. It also shows the rudiments of the buccal glands which are easily distinguished by their deeply staining capacity, and by the absence of cilia on their cells.

By this time the radular sac has increased in size, and its proximal portion shows a curvature which can be well seen in Text-fig. 12c. Moreover, the anterior part of its roof (upper part of the posterior wall in Text-fig. 12c) shows a slight outpushing directed posteriorly—this

is the rudiment of the sub-oesophageal pouch (cf. *Limax*, Meisenheimer, 1898). Text-fig. 12c is a sagittal section of the anterior part of the stomodaeum showing the vestibule, the odontophore and the radular sac along with the anterior part of the oesophagus. At this stage a thin transparent membrane is secreted by the basal epithelium which becomes thicker posteriorly—this membrane is the rudiment of the basal membrane. The cells which line the “knob” of the radular sac are the odontoblasts or the teeth-secreting cells of the radular sac. No teeth of the radula are yet visible, but changes leading to their formation have set in. The cells of roof of the radular sac increase in height. Their outer parts become hyaline and do not take up any stain, while their nuclei migrate inwards, i.e., towards the lumen of the sac. In the region of the odontoblasts, the nuclei are seen at different levels in the cells, thus apparently imparting to the latter a multi-nucleate appearance. But as has already been pointed out by Schnabel (1903) in the case of *Pabulina*, this is due to the apparent multiplicity of layers and not to the multi-nucleate character of the cells.

Text-figs. 13a, b, c are three transverse sections of the radular sac of slightly older embryos showing the development of the different rows



TEXT-FIG. 13. Stages in the development of the radular teeth.

a. Transverse section of the radular sac of an embryo in Stage 11, showing the formation of the lateral pair of radular teeth:  $\times 260$ ; b. Transverse section of the radular sac of an embryo in Stage 11, showing the formation of the inner pair of the marginal row of radular teeth:  $\times 260$ ; c. Transverse section of the radular sac of an embryo in Stage 12, showing all the seven rows of radular teeth:  $\times 260$ ; d. Sagittal section of the radular sac of an embryo in Stage 12:  $\times 320$ ; e. Sagittal section of the radular sac of a newly hatched embryo:  $\times 136$ .

of radular teeth secreted by the activity of the odontoblasts. Just before the formation of these teeth the basal membrane forms small projection over which lies the chitin secreted by the odontoblasts. In *Pila*, only seven teeth are laid in each transverse row, that is, two marginals and one lateral on each side of a median tooth (cf. *Paludina*, Bloch, 1896; and Schnabel, 1903). The rudiments of the lateral pair of teeth are differentiated first (Text-fig. 13a), followed by those of the inner pair of marginals (Text-fig. 13b). Those of the outer pair of marginals and the median tooth are differentiated last and arise almost simultaneously (Text-fig. 13c).

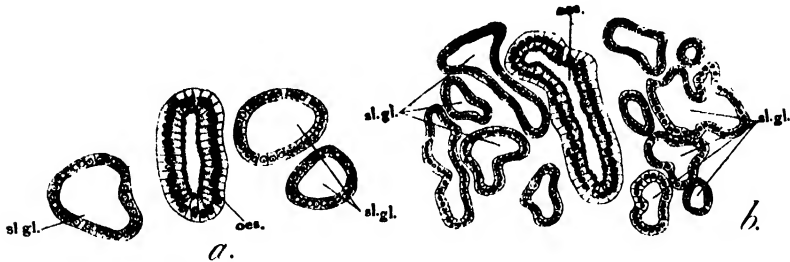
As development proceeds, the buccal cavity in the region of the sub-radular organ gives off two outpushings directed ventrally, one on each side: these are the rudiments of the sub-lingual cavity and are lined with a row of non-ciliated cells. Text-fig. 28f is a transverse section through the region of the sub-radular organ of an embryo belonging to Stage 12, and shows well developed sub-lingual cavities projecting as narrow chink-like prolongations of the buccal cavity.

In this stage, as well as in later stages, the ciliated cells of the buccal cavity extending from the sub-radular organ to its posterior limit, look completely hyaline, only the chromatin of the nuclei taking up the stain. Moreover, the cells are so arranged as to form a median groove running all along the roof of the buccal cavity up to its opening into the oesophagus (Text-figs. 26d, e). By this time the rudiments of the so-called cartilages have appeared by the modification of the closely packed mesenchyme cells lying ventrally to the arched odontophore. Text-fig. 11 is a sagittal section of an embryo of Stage 12, and shows the dorso-ventrally elongated cartilage of one side. I have not described the further development of these cartilages along with their muscles, as this has already been exhaustively dealt with by Delsman (1914) in *Littorina*. *Pila* agrees with *Littorina* as regards the origin and development of these cartilages and their associated muscles.

As development proceeds, all the structures described so far increase in size and become more defined. The jaw-rudiments make their appearance at a comparatively late stage, and lie dorso-laterally to the sub-radular organ, one on each side.

In the case of the radular sac, the roof epithelium loses its inner smooth surface on further growth, but forms cell-complexes instead, with nuclei lying at the inner ends of the cells which project in between the developing radular teeth on the opposite surface (Text-fig. 13e). The basal membrane forms a thick layer and extends all along the inner surface of the basal epithelium, while the roof epithelium projects in the form of cell-groups or complexes into the spaces in between the teeth which now show a hooked appearance. The roof epithelium takes no part in the formation of the teeth. The sub-oesophageal pouch is well developed. Text-fig. 14a is a sagittal section of the radular sac of a newly hatched embryo, and shows the odontoblasts retaining their original position at the blind end of the radular sac; the lumen of the radular sac persists and so does its communication with the buccal cavity, the lumen being wider, as in earlier stages, at the posterior end of the

radular sac than at its anterior. The radula appears as a long continuous ribbon passing over the odontophore and extending as far anteriorly as the radular organ. The roof epithelium of the sac now completely fills in the interspaces between the teeth which are now completely developed and have assumed their adult form. By this time the musculature of the buccal mass is also fully developed.



TEXT-FIG. 14. Development of the salivary glands.

- a.* Transverse section of the salivary glands of an embryo in Stage 11:  $\times 244$ .  
*b.* Transverse section of the salivary glands of an embryo in Stage 12:  $\times 244$ .

The salivary glands increase in size and become enlarged at their posterior ends into sac-like structures, while their anterior ends remain narrow and eventually form the ducts of these glands (Text-fig. 11). The glands are lined with a single layer of non-ciliated cubical cells with a rounded nucleus lying in the middle of each cell. Each nucleus has a distinct nucleolus in its centre which takes up a deeper stain than the chromatin of the nucleus itself. In the next stage of development the sac-like portions of the salivary glands begin to branch. Text-fig. 14*a* represents a transverse section passing through these sac-like portions, one on either side of the now laterally compressed oesophagus. The gland on the right shows two rounded sacs, the lower being a branch of the upper original sac. The left salivary gland shows the beginnings of a branch from the original sac. With further growth, these branches give out secondary branches, which in their turn branch again, so that by the time the embryo is ready to hatch, each salivary gland is composed of a large number of branching tubules extending in all directions (Text-fig. 14*b*). The salivary glands increase considerably in size and lie dorso-laterally on either side of the oesophagus. Each salivary gland has a common duct which runs anteriorly and then bends a little downwards to open into the lateral side of the buccal cavity, almost in the middle of the buccal gland of each side.

The oesophagus becomes considerably elongated (Stage 12) and runs backwards towards the visceral mass, opening at the anterior end of the primitive stomach now lined by the cells of the digestive-gland. This gland, though still lying in the head-vesicle, is very much reduced in size (Text-fig. 11), as compared with its earlier condition (Text-figs. 9 and 10). So far, the oesophagus has maintained its median position, but in stages subsequent to that shown in Text-fig. 11, in which the digestive-gland lies completely within the visceral mass, the oesophagus stretches throughout the length of the head-vesicle and deviates posteriorly from its median course towards the left (Text-fig. 26*f*), to open



into the stomach which is situated in the left ventral part of the visceral-sac. In these stages it is noticed that the oesophagus, after arising from the postero-dorsal end of the buccal cavity, runs obliquely downwards to enter the visceral sac. The connection of the head-vesicle with the visceral-sac has, due to a constriction and deep indentation of the mantle-cavity on the right side of the embryo, become so narrow that only the oesophagus and the columellar muscle can pass through. The oesophagus lies to the left of this muscle.

*Discussion.*—In some Gastropoda, e.g., *Littorina* (Delsman, 1914), *Limax* (Meisenheimer, 1898), *Physa* (Wierzejski, 1895), etc., when the embryo is passing from the gastrula to the trochophore stage, the blastopore shifts anteriorly from its original position and comes to lie almost immediately behind the velum. But the blastopore remains open and gives rise directly to the mouth, while the anus is a new formation. In some other Gastropoda, e.g., *Patella*, *Bythinia* and *Crepidula*, the blastopore, having shifted anteriorly, closes up; but, in spite of the closure, the stomodaeal invagination is formed at this very place.

In *Pila*, as in *Paludina* (Lankester, Erlanger, Fernando, etc.), on the other hand, the blastopore does not shift anteriorly but retains its original position; there it remains open and forms the anus. In *Pila*, therefore, the mouth is a new formation quite independent of the blastopore. The position of the mouth, however, corresponds exactly to that of other Gastropoda, i.e., the stomodaeal invagination is formed anteriorly on the ventral surface immediately behind the velum.

The buccal mass and the oesophagus, with all their accessory apparatus, i.e., sub-lingual cavities, oesophageal pouches, radular sac, and the salivary glands, which develop from the stomodaeum, are therefore ectodermal in origin. In *Limax*, however, Meisenheimer (1898) holds that the floor of the oesophagus is partly ectodermal and partly endodermal; the roof is completely ectodermal, while the side-walls show a transition from one layer to the other.

In all other Gastropods, e.g., *Paludina*, *Littorina* (Delsman, 1914), *Physa* (Wierzejski, 1905), Heteropoda (Fol, 1876) the entire fore-gut is ectodermal in origin.

As regards the radular sac, its origin and formation, as an evagination from the floor of the stomodaeum, are similar to those of other Gastropods. In almost all Gastropoda this evagination occurs after the stomodaeum has opened into the primitive stomach. In *Helix* (Fol, 1880), however, the rudiment of the radular sac appears even earlier than the joining of the stomodaeum with the archenteron.

In *Physa* (Wierzejski, 1905) the radular sac arises as a pair of structures which unite later to form a single-chambered sac. In this respect *Physa* is unique, as in no other Gastropod so far investigated, has a double origin of the radular sac been observed. In *Pila* the lumen of the radular sac does not completely disappear, but remains in constant communication with the buccal cavity. Schnabel (1903) describes a similar condition in *Paludina*. But in the Pulmonata (e.g., *Succinea*, *Helix*, *Planorbis*) this lumen disappears at the time of teeth formation. The Pulmonata and the Opisthobranchs (Rossler, 1885) are further characterised by a fixed number of odontoblasts, i.e., four to five. In

*Pila*, on the other hand, as in *Paludina* (Schnabel, 1903) and other Prosobranchs, and in Heteropoda (Rossler, 1885), there is no fixed number of odontoblasts; in fact, they are many, and they retain their terminal position to the last.

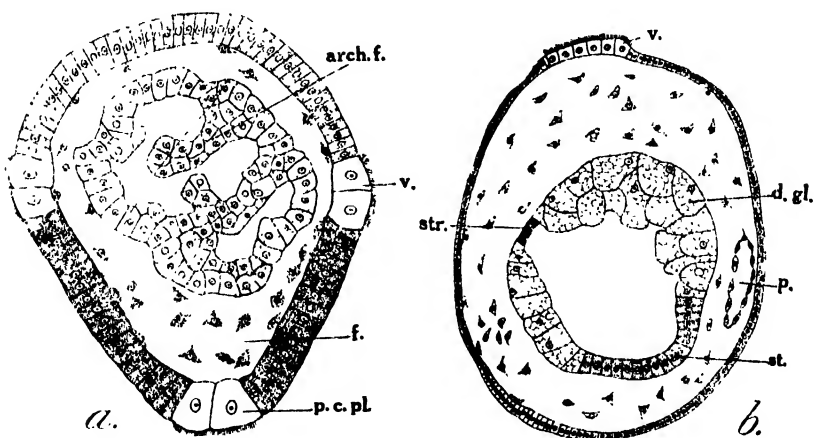
In *Littorina*, as in *Turbo* and *Patella*, the radular sac increases to such a length (Delsman, 1914) that, finding no place to accommodate itself, it deviates from its middle course towards the right (while the oesophagus lies on its left), and makes a spiral with the club-shaped end lying in the centre of the spiral.

#### *The Mesenteron.*

It has already been described that the archenteron gives rise anteriorly to the stomach and its digestive-gland and posteriorly to the intestine. I shall now first describe the development of the stomach and the digestive-gland, and then of the intestine.

#### *The Stomach and the digestive-gland.*

The cells forming the wall of the archenteron are laden with yolk which imparts to them a yellow tinge and also does not allow the cytoplasm to take up a deep stain; the nuclei, however, stain deeply. At an early stage, the boundary between the primitive stomach and the intestine cannot be easily made out and the two imperceptibly merge into each other, as all the cells are alike in size and shape (Text-figs. 6a, c). In the trochophore stage, just before the formation of the stomodaeum, however, the walls of the primitive stomach show internal folds (Text-figs. 6a and 15a). These folds are of various sizes in the different embryos of the same stage, and project into the lumen of the primitive stomach; that lumen is consequently greatly reduced. The wall of the primitive stomach thus provides an extensive surface for the absorption of the albuminous food. As development proceeds, the primitive stomach occupies greater and greater area within the



TEXT-FIG. 15. Development of the archenteric folds and the adult stomach.

a. Transverse section through the "Kopffuss" region of an embryo in Stage 3, showing the archenteric folds within the primitive stomach:  $\times 300$ ; b. Transverse section of an embryo in Stage 6, showing the differentiation of the adult stomach:  $\times 225$ .

"Kopffuss" region by the extension of its lumen, while the folds gradually dwindle away antero-posteriorly. The growth of the primitive stomach is due not so much to the multiplication of its cells as to the increase in their size.

As a result of the absorption and deposition of the ingested albumen, food-vacuoles appear at the inner ends of the large columnar cells of the primitive stomach. The vacuoles are very small to begin with, but gradually increase in size along with the growth in size of the cells; consequently, the nuclei are displaced from their middle position and are pushed to the outside where they come to lie at odd places. This indicates the first appearance of the digestive-gland<sup>1</sup>. The cells remain columnar and cylindrical but reach an enormous size. All the cells of the primitive stomach, become differentiated except at two places approximately opposite to each other. At these two places, the cells remain small and undifferentiated. The transition from undifferentiated cubical cells to the large vacuolated cells is gradual. In a whole embryo the two places appear as two clear zones or streaks amongst the hypertrophied cells of the digestive-gland rudiment. One of these streaks begins on the dorsal side at the junction of the oesophagus and the primitive stomach, and runs posteriorly, in an oblique direction, to a point where the intestine leaves the primitive stomach, keeping all along towards the right of the median line. The second streak lies imbedded in the left ventral part of the digestive-gland and leads posteriorly. The position of this streak is not constant but changes at different stages of development. In its earlier stages it is seen on the right of the median line (Text-fig. 15*b*), whence it changes in later stages to a mid-ventral position and finally comes to lie on the left wall of the primitive stomach. These clear streaks are the rudiments of the alimentary canal proper while the vacuolated lateral walls represent the digestive-gland. The ventral streak leads straight into the floor of the adult stomach (when formed), while the dorsal streak joins its roof (Stage 6).

Semper (1862) describes only one such streak in *Ampullaria polita* at a much later stage (*cf.* his fig. 15), which corresponds to the dorsal streak of *Pila*. Semper regards this streak as an independent structure which is only embedded within the wall of the digestive-gland, but I regard both the streaks as mere undifferentiated regions in the wall of the gland. Describing the appearance of the liver rudiment (digestive-gland), he says that it is hollow and the cavity is mostly full of bile-secretion. He apparently mistook the ingested albumen for bile-secretion. Scott (1934) also mentions only one streak in *Ampullaria canaliculata*. I am of the opinion that if these workers had cut sections of the embryos they would have seen the second streak of clear zone on the floor of the digestive-gland almost concealed by the large vacuolated cells.

The cells lining the posterior part of the floor of the primitive stomach on the right of the mid-ventral line, can be distinguished from the adjacent highly vacuolated cells; they are small and columnar, with a granular cytoplasm and a centrally situated nucleus (Text-fig. 16*a*). These cells represent the true stomach. The lumen of the primitive stomach enlarges to such an extent in the anterior part of

<sup>1</sup> This gland has been described as "liver" or has been given other equivalent names (*e.g.*, Leber, foie, etc.). But as Pelseneer (1905) and Prashad (1925) point out, the name "liver" is quite unsuitable, "for the gland combines the functions of the various digestive glands of the vertebrates and is, in addition, the chief organ for the absorption of the digested food".

the head-vesicle, that the dorsal wall of the latter becomes very much arched with a sharp anterior declivity in the region of the fore-gut, and a posterior gradual slope, where the stomach enters the visceral-sac rudiment (Text-fig. 5*d*).

With further growth the stomach first shifts completely to the mid-ventral line, but later comes to occupy its adult left-ventral position and lies completely within the visceral-sac (Text-figs. 9 ; 24*n* : and 25*b*).

After the true stomach comes to lie within the visceral-sac, the posterior rudiment of the digestive-gland lying dorsally to it (Text-fig. 24*n*) increases in size and extends posteriorly beyond the stomach up to the posterior end of the embryo. It thus forms a large sac-like structure with its lumen full of albumen (Text-figs. 10 ; 11 : and 26*a*, *b*). As development proceeds, the digestive-gland follows the course of the visceral-sac which, on account of the lateral torsion round a horizontal axis, passes from right to left, so as to produce an endogastric spiral—a characteristic of the visceral-sac of most Gastropoda.

With further development, while the posterior lobe of the digestive-gland shows a considerable increase in size and fills almost completely the cavity of the visceral-sac, displacing the other organs dorsally, the anterior lobe is reduced in size (Stage 12 : Text-fig. 11).

By this time the cavity of the digestive-gland is almost completely filled up with the ingested albumen which is completely absorbed by the time the embryo hatches. As there is no more space available for the digestive-gland to expand, lobes develop on its inner surface which increase in number and completely obliterate the lumen. Thus the lobed character of the gland, consisting of long follicles characteristic of adult *Pila*, is obtained.

*Previous work and discussion.* Thus, in *Pila*, the adult stomach arises from the right side of the floor of the posterior end of the stomach. In *Bythinia* (Erlanger, 1892) the stomach is differentiated at the postero-dorsal part of the endodermal sac. In *Littorina* also, the posterior part forms the stomach. In *Paludina* (Bütschli, 1877 : and others), on the other hand, it is the dorsal and the anterior part of the primitive stomach which gives rise to the adult stomach.

On comparing the origin of the digestive-gland in *Pila* with that of other Gastropoda, we find that there is a great variation, apparently due to the different positions of the areas of storage of the nutritive material within the endoderm.

In *Paludina* (Erlanger, 1891 ; Drummond 1903 ; and Otto and Tönniges, 1905), the "liver" (digestive-gland) arises as a single rudiment from the floor of the endodermal sac, the cells of which increase in size and become vacuolated. The dorsal anterior part follows suit, but it is always on the ventral side that there is greater accumulation of nutritive substances and consequent formation of the "liver" rudiment.

In *Bythinia* (Erlanger, 1892), the "liver" arises in the form of two outgrowths—an anterior, which is larger, wider and dorsal in position ; and a posterior which is smaller and ventral in position.

In *Littorina* (Delsman, 1914), the "liver" arises as an unpaired structure from the left wall of the endodermal sac, and is directed dorsally. But it is divided later into two lobes of unequal size ; the larger

one lies anteriorly to the stomach, while the posterior one, which is smaller, lies to the right of the stomach.

In *Planorbis* (Rabl, 1879) and other Pulmonates (Fol, 1880; Jourdain, 1884), the "liver" arises from the antero-dorsal vacuolated part of the endodermal sac, the stomach originating from the posterior part. These rudiments of the liver and stomach later become separated by the appearance of a partition between them. In *Limax* (Meisenheimer, 1898), the "liver" arises as two rudiments, the anterior left, and the posterior right, arising chiefly from the anterior part of the primitive stomach. Only the left rudiment, which consists of two parts, forms the "liver" of the adult.

### *The Intestine.*

To begin with, the cells lining the intestine are of the same shape and size as those of the primitive stomach (Text-figs. 6a-d). In later stages, however, while the cells of the primitive stomach become large and vacuolated and give rise to the rudiments of the digestive-gland, those of the intestine become columnar and thickly granulated, and remain non-vacuolated, and thus the boundary between the two structures can be easily made out (Text-fig. 7b). In the earliest stages the intestine possesses a broader lumen anteriorly near its junction with the primitive stomach than it does posteriorly (Text-figs. 6a-d); in later stages, however, there is a uniform rounded lumen along its entire length (Text-fig. 7b).

In its earliest stages, when the embryo is bilaterally symmetrical, the intestine runs a straight median course extending from the posterior end of the primitive stomach to the anus (Text-fig. 6a). But later, it is displaced out of its median course and is pushed towards the left (Stage 4; Text-fig. 16b). At a still later stage, as a result of torsion, a ventral flexure appears in the intestine (Stage 5) and it elongates and becomes displaced towards the right side (Stage 7). By the time torsion is complete (Stage 10), the intestine arises from the left postero-dorsal side of the stomach and courses round the hinder end of the digestive-gland towards the right; it then turns upwards and reaches the anterior face of the visceral-sac to open into the mantle-cavity through the anus.

The blastopore persists and forms the anus, there being no trace of a proctodaeum.

*Previous work and discussion* :—Semper (1862) and Scott (1934) do not make any mention of the persistence of the blastopore and the formation of the anus in *Ampullaria polita* and *A. canaliculata*. But from Semper's description it appears that the rudiment of the intestine arises from the primitive stomach to open out through the anus (his fig. 7, Pl. I). Similarly, according to Fernando's description of a stage in *Pila gigas* where he says "it is a trochophore in which the intestine has not yet opened to the outside", it appears that the blastopore does not persist to form the anus, but that the latter is a new formation. The failure of Semper and of Scott to notice the opening of the intestine to the outside was due to the fact that they worked on whole

embryos, which are full of yolk and consequently opaque at this stage, and it is almost impossible to observe internal structures correctly. The only explanation for Fernando's mistake can be that his sections were probably not properly orientated or that Fernando might have cut sections more than  $4\ \mu$  thick, in which case there is every possibility of his having missed the anal opening. These suppositions are strengthened by the fact that Fernando, in his fig. 1, Pl. I, shows the shell-gland as 7 to 8 cells thick, while in reality at this stage it consists of a single layer of cells. It can only appear many-layered if the sections are oblique.

*Paludina* (Erlanger, 1891; Fernando, 1931) resembles *Pila* in the fact that the blastopore persists and forms the anus, and there is no trace of an ectodermal invagination.

In the majority of Gastropoda, the intestine arises as a posterior prolongation of the endodermal "primitive stomach", which later meets with the ectoderm of the body-wall, and, breaking through it, opens to the outside through the anus. Thus it is held that a very small proctodaeum is formed.

In *Lymnaea* (Lankester, 1874) a "pedicle of invagination" is formed where the blastopore closes "which grows up against the primitive alimentary cavity and finally unites with it".

In *Planorbis* (Rabl, 1879), *Umbrella* (Heymons, 1893), and *Physa* (Wierzejski, 1905), the intestine originates as a solid band of cells, in which a lumen is formed later. In *Physa*, towards the posterior end of this band, two large ectodermal cells appear in the body-wall of the embryo; here a shallow ectodermal invagination occurs, but it does not give rise to any part of the actual or true intestine.

In *Limax* (Meisenheimer, 1898), the entire intestine right up to its opening into the stomach is ectodermal in origin. According to him, the ectodermal invagination is formed with a very narrow lumen. In later stages, the lumen becomes rounded and the invagination becomes cut off from the outer ectoderm and fuses with the endoderm so that it can easily be mistaken for an evagination from the latter. Later it elongates and opens again to the outside through the anus which is thus a secondary formation. This point, in my opinion, needs confirmation.

#### B. *The Differentiation of the Common Rudiment of the Kidney, the Pericardium, the Heart and the Gonad.*

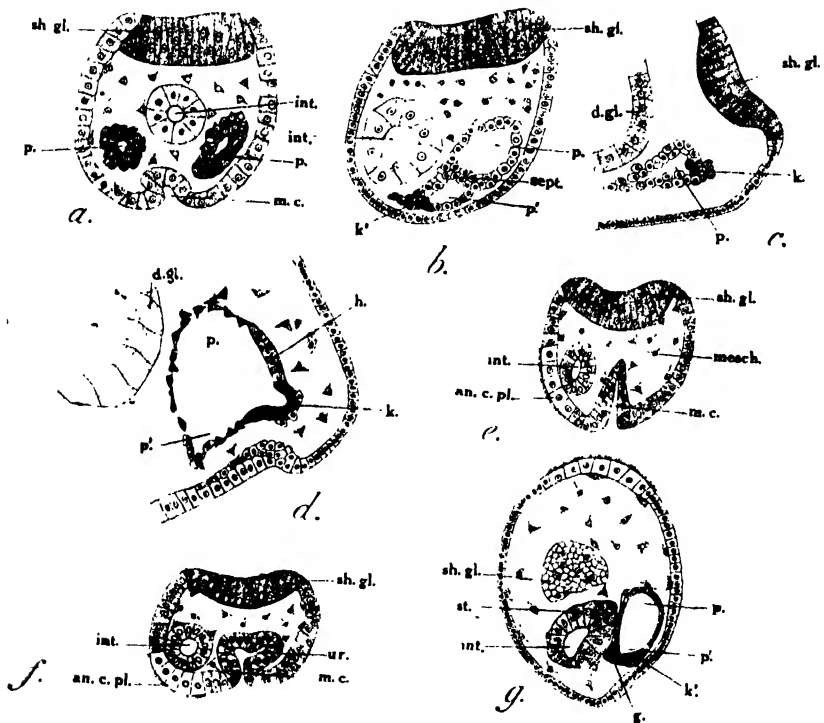
The appearance of two small compact masses of mesenchyme cells at the postero-ventral part of the embryo has already been described in Stage 2 above. These cell-masses are formed below the level of the intestine, one on either side by the aggregation of mesenchyme cells (Text-fig. 6b). They are irregular in shape and of unequal size, the right mass being larger than the left.

Soon a small cavity appears in the cell-mass of the right side; it is immediately followed by the formation of a similar cavity in the left one. Each cavity is formed by the separation of mesenchyme cells from one another in the centre of each cell-mass, but is not delimited by a regular epithelium. The two cavities, like the cell-masses, are

unequal in size, the right cavity being always larger than the left (Text-fig. 16a). These two cell-masses with their cavities form the rudiments of the pericardium.

As development proceeds, the pericardial rudiments increase in size and move towards each other and meet beneath the intestine. the cavity of the right pericardial rudiment still remaining larger than that of the left. The growth of the two rudiments occurs in such a manner that, while the cavity on the right side develops in all directions, the left cavity develops more towards the median plane. Although the two rudiments lie against each other, their cavities are separated by a septum many cells in thickness.

With further development, the two pericardial rudiments shift from their ventral position to the right side of the intestine. On account of greater increase in the size of the right cavity, its wall becomes thinned to a single layer of cells. Gradually, the other cavity also



TEXT-FIG. 16. Early stages in the differentiation of the rudiment of the kidneys, the pericardium, the heart and the gonad.

a. Transverse section of an embryo in Stage 2, passing through the right and left pericardial rudiments and the invagination of the mantle-cavity rudiment:  $\times 320$ ; b. Transverse section of an embryo in Stage 1, passing through the rudiment of the left kidney and the septum between the two pericardial rudiments:  $\times 320$ ; c. Sagittal section passing through the right pericardium, showing the formation of the right kidney rudiment:  $\times 304$ ; d. Sagittal section passing through the pericardium, and showing the differentiation of the heart rudiment:  $\times 292$ ; e. Transverse section of the embryo in Stage 3, passing through the mantle-cavity rudiment:  $\times 264$ ; f. Transverse section of an embryo in Stage 4, showing the evagination of the right ureter from the mantle-cavity:  $\times 252$ ; g. Transverse section of an embryo in Stage 5, passing through the gonad and the left kidney rudiment:  $\times 204$ .

become bounded by a single layer of cells. The two cavities are still separated from each other by the septum which has now become thin and consists of one or two layers of cells. It is from these two mesenchymatous rudiments of the pericardium that the kidneys, the pericardium, the heart and the gonads arise.

*Discussion* :—Fernando's (1931) observations regarding the formation of the mesenchymatous rudiments of the pericardium in *Pila gigas* differ in some details from those of mine. According to him, the left pericardial rudiment is formed later when the rudiment of the right pericardium, leaving its ventral position, "has come to lie on the right of the intestine, and the cells are so arranged as to enclose a lumen—the right pericardium". It is at this stage that the left pericardial rudiment is formed as "a very small cavity". I think Fernando failed to observe the formation of the left pericardial rudiment when it still lies ventrally to the intestine as a solid compact mass like that of the right pericardial rudiment, as is generally the case in all Gastropods which have paired rudiments of the pericardium, as in *Paludina* and *Physa*. Again, though the left pericardial rudiment arises, according to Fernando's description, as well as his fig. 2, Pl. I, later than that of the right pericardium, and its lumen is also much smaller than that of the latter. Yet in his fig. 4, Pl. I, Fernando has shown the left pericardium to be almost as large as the right one, which can only happen if it shows a quicker and stronger development than that of the right pericardium. But this is contrary to the actual facts, since the lumen of the right pericardium, besides appearing earlier than that of the left pericardium, as Fernando himself points out, remains much larger than that of the left. Another difference consists in regard to the positions of the two pericardial rudiments in relation to each other. As seen in fig. 4, Pl. I, of Fernando, the rudiment of the left pericardium lies between the rudiment of the right pericardium and the intestine, while according to my observations, at a stage corresponding to the one represented by fig. 4, Pl. I, of Fernando, the rudiment of the left pericardium, though it has shifted to the right of the intestine, yet lies ventrally to the right pericardium but closely applied to it (Text-fig. 16*b*). I cut horizontal sections also of such a stage and they confirmed my observations. My observations are in complete agreement with those of Erlanger (1891), Drummond (1903), and Otto and Töniges (1905) in *Paludina* (= *Viviparus*). Hence I consider that the observations of Fernando in *Pila gigas* require revision.

#### *The kidneys.*

The rudiments of the kidneys make their appearance at a stage when the rudiments of the right and left pericardium, separated from each other by a median septum, still lie below the level of the intestine (Stage 3). A thickening appears at the postero-ventral end of the right pericardium (Text-fig. 16*c*), which is followed immediately by the formation of another but smaller thickening in the wall of the corresponding region of the left pericardium. These two thickenings are the rudiments of the right and left kidneys respectively. With further development an evagination takes place in the right kidney rudiment



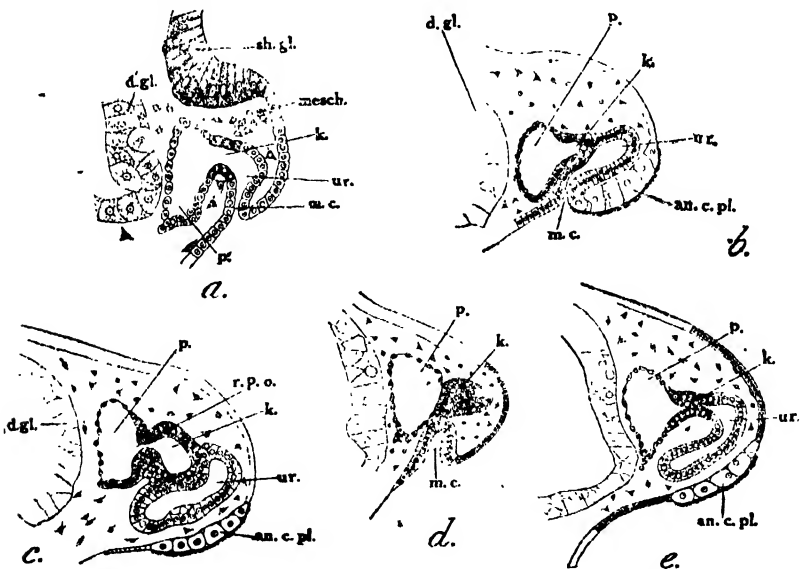
which deepens and gives it a more or less vesicular appearance (Text-fig. 16*d*). Meanwhile the left kidney rudiment continues as a mere thickening (Text-fig. 16*c*). The right kidney rudiment is distinguished by the thickly granulated character of its cells which, by this time, assume a columnar shape and form a regular epithelium for the kidney.

While the right kidney rudiment has developed into an open vesicle lined by a regular epithelium, another structure, which comes into relation with it later, makes its appearance; it is the rudiment of the ureter (=anterior kidney). The rudiment of the mantle-cavity (Stage 1) grows deeper and acquires a lumen (Text-fig. 16*e*), and from its inner right end a tubular evagination arises towards the right side (Text-fig. 16*b*)—this is the rudiment of the ureter. While keeping towards the right side within the visceral-sac rudiment, it grows posteriorly and ascends obliquely upwards and comes to lie against the posterior end of the open vesicular rudiment of the right kidney into which it finally opens.

The rudiment of the left kidney still persists as a thickening, its cavity and evagination appearing much later; there is no trace yet of the rudiment of the ureter of the left side.

In *Pila* the rudiments of both the kidneys, that is, the right and the left, are laid in the earliest stages of development and are mesodermal in origin, while the ureter is ectodermal.

*Discussion* :—Semper (1862) makes no mention of the right and left rudiments, but from his description it is evident that he describes only



TEXT-FIG. 17. Stages in the development of the kidneys and the ureter.

a. Oblique sagittal section of the embryo in Stage 4, showing the opening of the right kidney into the ureter:  $\times 312$ ; b. Sagittal section of the embryo in Stage 5, showing the wide lumen of the right ureter:  $\times 176$ ; c. Sagittal section of the embryo in Stage 6, passing through the renal-pericardial aperture:  $\times 176$ ; d. Sagittal section of the embryo in Stage 6, showing the relation of the mantle-cavity with the pericardium and the right kidney:  $\times 180$ ; e. Sagittal section, showing the bending forward of the ureter to meet the kidney:  $\times 180$ .

the origin of the functional left kidney (=morphologically right). According to him, the cells which form the rudiment of the kidney "arise by transformation directly out of the epidermis cells", i.e., they are ectodermal in origin. But the stage at which he observed this rudiment of the kidney as well as the position of these cells in his fig. 21, Pl. III. at once make it clear that Semper was unable to observe or locate the origin and the formation of the kidney in *Ampullaria polita*.

Fernando's description of the origin of the kidney in *Pila gigas* (1931) is almost in complete agreement with my observations, with the only exception that he considers the formation of the rudiment of the right kidney to arise first by evagination, which, according to my observations, is the second stage of development, the first being the thickening stage. He has also shown that while the kidney proper is mesodermal in origin, its ureter is ectodermal.

Scott (1934) makes no reference to the left kidney rudiment in *Ampullaria canaliculata*. Similarly, she does not describe the nature and manner of the origin of the kidney. She only describes the presence of a kidney-pericardium complex which she observed for the first time at a pretty late stage when the ureter is already opening to the exterior (cf. her fig. 17).

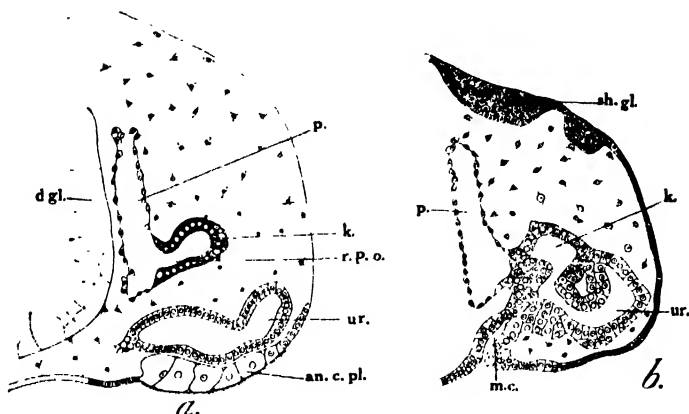
#### *The pericardium and the heart.*

It has already been described that the rudiments of the right and left pericardium, even after they come to lie against each other, are still separated by a septum which is quite thick to begin with, but becomes thinner later on (Text-fig. 16*b*). Even at this stage the difference in the size of the two sacs of the pericardium is well marked, the right one (now dorsal in position) being much larger and broader than the left (now ventral in position) which is very narrow at its inner ventral end. As development proceeds, the septum becomes reduced and is gradually absorbed antero-posteriorly. By the time the embryo reaches Stage 5, it disappears completely by being absorbed into the wall of the pericardium-sacs, which now form a single large thin-walled sac, lying completely on the right side of the gastro-intestinal junction. This sac forms the adult pericardium in which the heart is differentiated later (Text-figs. 4*c-h* ; 5*a-f* ; and 16*d*).

Just when the pericardium comes to lie on the right side of the gastro-intestinal junction as a single chamber, a part of the pericardial wall lying anteriorly but dorsally to the right kidney becomes thickened, and is thus distinguishable from the adjoining area of the pericardial wall. This thickening really lies in the original rudiment of the right pericardium and forms the rudiment of the heart (Text-fig. 16*d*). It invaginates into the pericardial chamber and gives rise to the heart. Thus, unlike the rudiments of the right and left kidney and those of the right and left pericardium, the heart arises as a single unpaired rudiment inside the cavity of the original right pericardium.

Even in later stages of development, it is that part of the pericardium which corresponds to its original right rudiment that grows more and increases in dimensions, while the original left pericardial rudiment

remains small, and corresponds to the narrow part of the pericardium in later stages.



TEXT-FIG. 18. Relation of the right kidney and the ureter.

*a.* Sagittal section of the embryo in Stage 8, passing through the reno-pericardial aperture and showing the dorsal bending of the right kidney :  $\times 225$ ; *b.* Another sagittal section of the same embryo in (*a*), passing through the opening of the ureter into the right kidney :  $\times 225$ .

### *The gonad.*

After the differentiation of the right and left kidney rudiments as well as that of the heart, another cell-thickening makes its appearance in the roof of the narrower left part of the pericardium, situated ventrally to the gastro-intestinal junction—this is the rudiment of the gonad. Text-fig. 16*g* is a transverse section passing through the gonad-rudiment of an embryo, which is slightly older than the one in which the gonad rudiment is first laid; hence the gonad rudiment, instead of being exactly ventral, lies a little to the right of the gastro-intestinal junction. At the stage at which it is first differentiated, the larger part of the thin-walled pericardium (right pericardial sac) lies on the right side between the gut and the body-wall; while the left pericardial sac still lies partly ventrally to the gastro-intestinal junction. It is on the roof of this narrower part of the pericardium, almost on its extreme left, that the rudiment of the gonad is first laid. It lies dorsally, close to the rudiment of the left kidney, with which it is very closely associated.

The cells of the gonad rudiment proliferate and extend along the wall of the digestive gland in the form of a cord of cells. Text-figs. 16*g* and 20*c* pass through the gonad rudiment and show its relative position with regard to the rudiment of the left kidney and other structures.

*Discussion* :—Semper (1862) mistook an advanced stage of the gonad for its first rudiment ("erste anlage") at a stage at which "the shell has already made one complete spiral and has thus surrounded the liver (=digestive gland), a part of the latter still lying within the head-vesicle" (*cf.* his fig. 25, Pl. IV). At this stage, according to him, the gonad lies at the apex of the spiral as a glandular mass of small greyish cells in contrast to the yellow mass of the liver. But this, as is apparent

from his description, is a much later stage in which the distal end of the gonad has also participated in the spiral of the digestive gland. Semper, however, does not allude to the origin (mesodermal or otherwise) of the rudiment of the genital gland.

Fernando (1931) on the other hand, has overlooked the formation of the gonad rudiment in *Pila gigas* and believes it to be post-embryonic in formation.

A comparison of the origin of these organs, *i.e.*, the kidney, the pericardium, the heart and the gonad in different Molluscs reveals great variations. These variations concern the following main points: (1) whether there is only one common rudiment for all these organs, or each of these organs has an independent origin; (2) whether all these organs are mesodermal or ectodermal in origin or whether some are mesodermal, and others ectodermal; and (3) whether the common rudiment, if present, is paired or unpaired.

I shall discuss below these three points in the order given above.

(1) In nearly all the Lamellibranchs and the following forms amongst the Gastropoda, all the organs, that is the kidney, the pericardium, the heart and the gonad are differentiated from a common rudiment: *Pila*, *Paludina*, (Erlanger, 1891; Otto and Tönniges, 1905), *Littorina* (Delsman, 1914), *Planorbis* (Rabl, 1879), *Physa* (Wierzejski, 1905).

*Paludina* (Erlanger, 1891; Drummond, 1903; Otto and Tönniges, 1905) shows the greatest resemblance to *Pila* with regard to the development of the paired common rudiment.

There are other forms, such as *Calyptrea* and *Vermetus* (Salensky, 1872) and *Bythinia* (Erlanger, 1892) amongst Prosobranchs, and *Arion* (Heyder, 1909) and *Limax* (Hoffmann, 1922) amongst Pulmonates, in which only the kidney, the pericardium and the heart form a common rudiment, while the gonad rudiment arises independently.

(2) Again, there is either an actual variation, or probably only a difference of opinion as to the mesodermal or ectodermal origin of these rudiments. For example, Erlanger (1891) and Fernando (1931) describe the common rudiment as mesodermal in origin, while Tönniges (1896) and Otto and Tönniges (1905) describe it as ectodermal. According to the latter authors, the paired rudiment arises directly, one on each side of the middle line, by the inward growth of the ectodermal cells from the body-wall, and thus gives rise to two irregular compact cell-masses. But this view has been rejected by a great many authors like MacBride (1915), Heyder (1909), Naef (1913), Herbers (1914), Fernando (1931) and others, who have remarked that those authors who believe in the ectodermal origin of the common rudiment are certainly wrong, and that cell-masses forming the common rudiment arise through the division of the primary mesoderm cells. According to these authors, the ectodermal nature of the rudiment is an illusion due to the close proximity of these rudiments to the ectodermal wall.

(3) Regarding the paired or unpaired character of the common rudiment, we find that in majority of cases it is a paired structure lying in the posterior part of the embryo, as in *Paludina*, *Bythinia*, *Physa*, *Arion*, *Planorbis*, *Anodonta*, and *Ostrea*. On the other hand, in *Limax* (1898) and *Dreissensia* (1901), according to Meisenheimer, the common

rudiment is an unpaired structure, but while it is asymmetrical in *Limax*, it is symmetrical in *Dreissensia* as it is mid-ventral in position.

### *Further Differentiation of the Separate Rudiments.*

#### *The kidney.*

In *Pila*, the kidney originates in two parts. These are: (1) the kidney proper, and (2) the ureter.

While there are differences of opinion regarding the mesodermal or ectodermal origin of the kidney proper, there is more or less unanimity on the ectodermal origin of the ureter, which arises as an invagination from the mantle-cavity.

Erlanger describes the kidney in *Paludina* (1891) and *Bythinia* as arising from the posterior wall of the pericardium (cf. Otto and Tönniges, 1905), and later fusing with the ureter to communicate with the mantle-cavity. In *Littorina* (Delsman, 1914), the kidney does not arise as an evagination from the pericardium, but develops into a vesicle even before the appearance of a lumen in the pericardial part.

#### *The heart.*

With regard to the differentiation of the heart in the Mollusca there is greater agreement amongst the various observers as to the mesodermal origin of the heart and the pericardium, than is the case with the kidney. The exceptions are few and are connected with those cases where the common rudiment for both the kidney and the heart has been taken to be ectodermal in origin.

While according to Bütschli (1877) and Erlanger (1891), the rudiment of the pericardium and the heart in *Paludina* (= *Viviparus*) is mesodermal, Otto and Tönniges (1905) hold it to be ectodermal. Recently, however, Fernando (1931) has proved its mesodermal character. Similarly, Erlanger (1892) in *Bythinia*, Salensky (1872) in *Calyptrea* and *Vernetus*, Delsman (1914) in *Littorina*, Bobretzsky (1877) in *Nassa*, and Fol (1880), Pöetzsch (1904), Wierzejski (1905), Heyder (1909) in the Pulmonates, *Planorbis*, *Physa*, *Arion*, etc., have described the pericardium and the heart to be of mesodermal origin. Meisenheimer, however, describes the heart rudiment in *Limax maximus* (1898), *Cyclas* (1901) and *Dreissensia* (1901) to be ectodermal; but we find that Schalfcew (1888) and Ziegler (1885) had already traced the mesodermal character of these in *Limax agrestis* and *Cyclas* respectively.

### (c) *The Kidneys and the Ureter.*

#### *The Right or Functional Kidney and its Ureter.*

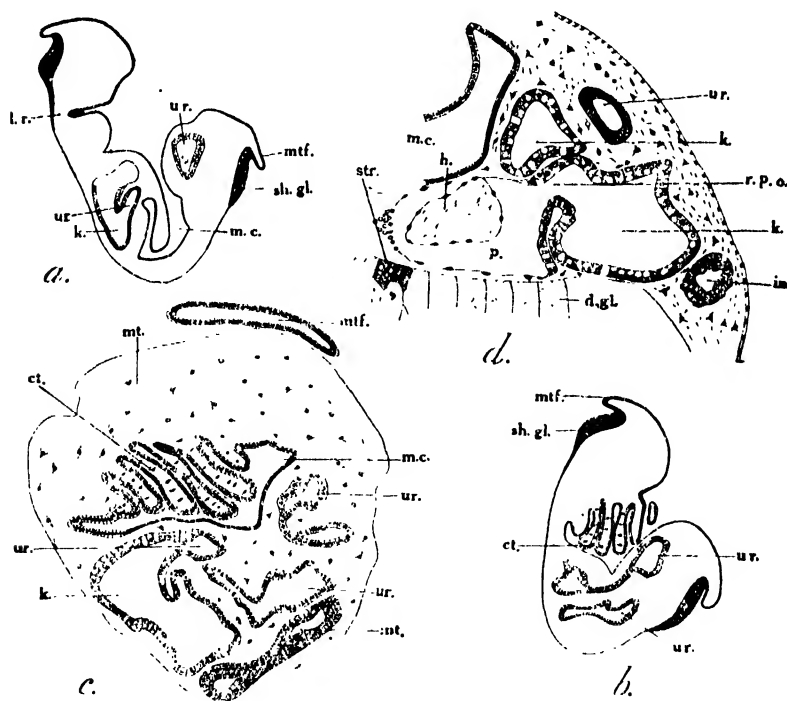
In the preceding part it has been described that the rudiment of the right kidney on evagination from the pericardium forms a small, open pouch communicating widely with the pericardium, and that the ureter, on evagination from the mantle-cavity, forms a tubular structure which, on further development, comes to lie against the posterior end of the right kidney.

As development proceeds (cf. Stage 4, Text-fig. 4 c) a cytolysis of cells, as has already been described and figured by Fernando (1931)

in his fig. 5, Pl. II, takes place at the junction of the right kidney and the ureter with the result that a communication is established between the two (Text-fig. 14 d).

In the next stage of development (Stage 5, Text-figs. 4 d, e) the kidney has grown in length and appears more or less tubular in shape and is directed backwards where it communicates with the ureter. The ureter, in turn, possesses a lumen uniformly in continuation with that of the mantle-cavity, rendering it difficult to mark off the boundary between the two. Starting from the mantle-cavity, the ureter first leads backwards and then upwards to open into the posterior end of the kidney, but it has a wider lumen at its kidney-end than at its mantle-cavity-end. The wide communication of the kidney with the pericardium (Text-fig. 17 b) lies to the right of the opening of the ureter into the kidney. As the tubular ureter increases in length, its kidney-end forms a bend just before opening into the right kidney (Text-fig. 17 c).

In the next stage (Stage 6, Text-fig. 4 b) the mantle-cavity grows inwards and upwards and comes to lie almost against the postero-ventral pericardial wall, just near the place where the kidney opens into the pericardium (Text-fig. 17 d). It is from this inner end of the mantle-



TEXT-FIG. 19. Stages in the development of the kidneys and the ureter.

a. Transverse section of an embryo in Stage 10, showing the opening of the ureter into the kidney and the mantle-cavity:  $\times 156$ ; b. Transverse section of an embryo in Stage 10, passing through the gill filaments and the ureter:  $\times 156$ ; c. Transverse section of an embryo in Stage 11, passing through the opening of the ureter into the kidney, and showing the gill filaments hanging into the mantle-cavity:  $\times 116$ ; d. Sagittal section of an embryo in Stage 11, passing through the reno-pericardial aperture, and showing the formation of the vacuoles within the kidney walls:  $\times 176$ .

cavity that the ureter arises and runs backwards and upwards, reaching as far back as the middle of the posterior wall of the embryo (Text-figs. 4 c and 17 a). The right kidney, arising from the postero-ventral wall of the pericardium, leads straight back to open into the now anteriorly directed end of the ureter (Text-figs. 4 c and 17 e). At this stage the opening of the ureter into the mantle-cavity lies to the left of the outer opening of the mantle-cavity. A study of a series of sagittal sections of the embryo at this stage shows that the opening of the ureter into the kidney lies to the right of the opening of the ureter into the mantle-cavity (Text-fig. 7 a), but to the left of the external opening of the mantle-cavity. In fact, the greater part of the ureter lies to the left of the kidney and the pericardium. The left inner wall of the ureter lies in the same plane as the intestine and the inner surface of the invaginated shell-gland.

As development proceeds (Text-fig. 4 f), the right kidney grows in size and becomes a more or less rounded sac communicating with the pericardium through a narrow aperture, the reno-pericardial aperture, which lies to the left of the opening of the kidney into the ureter. The kidney already shows indications of turning upwards, (Text-figs. 4 f and 7 a), to lie against the posterior wall of the pericardium in later stages. The ureter is now a long tubular structure which runs posteriorly and keeps near the floor of the visceral-sac rudiment on the right side.

In the next stage (Stage 7, Text-fig. 4 h), the kidney has grown larger in size and shows a bend towards the dorsal side (Text-figs. 4 h and 8 a), though the reno-pericardial aperture still retains its original position. Moreover, the posterior part of the kidney shows a bulge towards its right, with the result that in sagittal sections the kidney appears to be divided into two chambers, while in reality (as a reconstruction of these sections shows) there is only one chamber with a swelling on the right side. It is into this swollen part that the ureter now opens at its postero-ventral region (Text-fig. 8 a). The opening is comparatively narrow and lies posteriorly, and to the right of the reno-pericardial aperture.

The mantle-cavity has become wide and lies, as in the preceding stage, against the postero-ventral pericardial wall. Arising from the mantle-cavity through a narrow opening (Text-fig. 4 h), the ureter now leads downwards and backwards and lies against the postero-ventral part of the visceral-sac rudiment (Text-fig. 18 a), whence it runs upwards and forward to enter the kidney (Text-fig. 4 h). As development proceeds, the ureter describes a wide bend at the postero-ventral end of the visceral-sac rudiment on its right. After reaching about the middle of the height of the visceral-sac rudiment, it bends forward again and opens into the kidney as described above (Text-fig. 18 b). Thus, the ureter has got two limbs running almost parallel to each other, one being ventral and communicating anteriorly with the mantle-cavity, while the second is dorsal and opens anteriorly into the kidney. The loop connecting these two limbs lies at the extreme posterior end of the embryo.

In the next stage of development (Stage 8, Text-fig. 5 a) in which the pericardium lies completely on the dorsal side immediately above the gastro-intestinal junction, and the mantle-cavity has grown wider

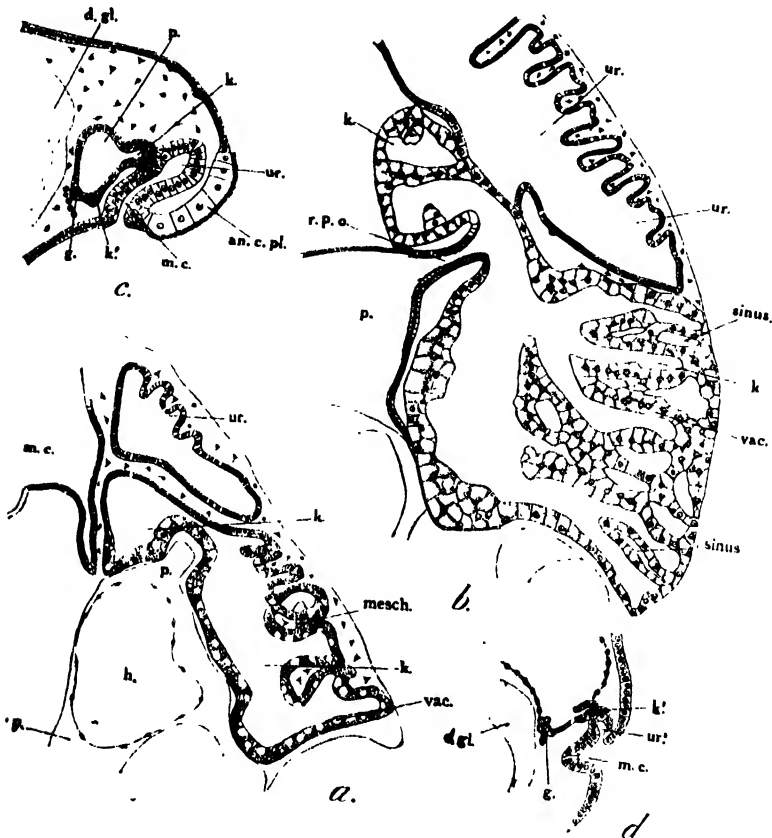
and lies almost midway between its former ventral and future dorsal position (Text-fig. 5 *a*), the limbs of the ureter no longer remain parallel to each other but form one closed loop. Part of this looped ureter now lies in the postero-ventral part of the embryo, while the remaining part retains its original position. The kidney has grown much in size and has a broad cavity within it. The opening of the kidney into the ureter still lies to the right of but ventrally to the reno-pericardial aperture, which is a clear proof of the fact that the ureter has now come farther forward. The opening of the ureter into the mantle-cavity is a narrow elongated aperture (Text-fig. 5 *a*) situated to the right of and ventrally to the opening of the ureter into the right kidney, so that all the three openings are situated almost in the same line. Text-fig. 8 *b* is a sagittal section of a slightly older embryo (Stage 9) passing through the opening of the ureter into the mantle-cavity, in which a part of the ureter situated dorsally runs to open into the kidney, the actual opening not being seen in the plane of the section.

In Stage 10 (Text-figs. 5 *b*, *c*) torsion has completed and the wide and spacious pericardium has passed over completely to the left side of the embryo, carrying the kidney along with it. The large mantle-cavity occupies its final and definitive dorsal position and leads ventrally and to the right through a narrow elongated aperture into the loop of the ureter which lies mainly in the right half of the visceral sac (Text-figs. 19 *a*, *b*). The ureter is now a long tubular structure bent on itself; from the mantle-cavity it runs first posteriorly and then follows a tortuous course to open dorsally into the kidney (Text-fig. 19 *a*). The kidney has enlarged and stretches posteriorly so as to lie against the posterior wall of the pericardium but a little to the right of it (Text-fig. 9). Though the kidney has passed over to the left side of the embryo, the reno-pericardial aperture which was so far ventral in position, now lies, dorsally and to the left of the opening of the ureter into the kidney. Thus, at this stage, the mantle-cavity as well as the ureter come to lie dorsal to the level of the kidney.

In the next stage (Stage 11, Text-figs. 5 *d*, *e*) the kidney increases considerably in size and appears rhomboidal in transverse sections (Text-fig. 19 *c*). Anteriorly it lies wedged in between the pericardium on the left and the posterior part of the digestive-gland on the right, with the anterior part of the intestine passing beneath it. At this stage, it shows the first indication of folds which project into its lumen from its posterior as well as its left wall. It opens dorsally into the pericardium at its extreme right postero-dorsal end (Text-fig. 19 *d*), close to the opening of the kidney into the ureter. The mantle-cavity communicates with the ureter through a narrow elongated aperture which lies to the right of and posterior to the reno-pericardial aperture. The part of the ureter which extends behind this region lies horizontally extended posteriorly, below the posterior extension of the mantle-cavity. At this stage a part of the loop of the now very much elongated ureter is situated within the wall of the mantle on the right side of the visceral sac, and extends forward to the anterior end of the kidney. Both the openings of the ureter into the mantle-cavity and of the kidney into the ureter lie behind this part of the ureter.



As development proceeds, the kidney grows larger but is so situated that it cannot grow freely in all directions. Anteriorly it is bounded



TEXT-FIG. 20. Further stages in the development of the kidneys and the ureter.

*a.* Sagittal section of an embryo in Stage 12, showing the formation of folds in the kidney and the ureter:  $\times 119$ ; *b.* Sagittal section of an embryo ready to hatch, passing through the reno-pericardial aperture and showing the lamellar condition of the kidney and the ureter:  $\times 96$ ; *c.* Sagittal section of an embryo in Stage 5, passing through the gonad and left kidney rudiments, and showing the differentiation of the left ureter as a depression in the wall of the mantle-cavity:  $\times 206$ ; *d.* Oblique transverse section showing the left ureter evaginating from the mantle-cavity and abutting against the blind end of the evaginating left rudimentary kidney:  $\times 264$ .

by the pericardium, on the left it lies against the wall of the visceral-sac covered over by the shell, on its anterior right lies the posterior end of the digestive-gland, on its posterior right the ureter, while dorsally lie the ureter and the floor of the mantle-cavity. Thus, the kidney is closely pressed on all sides by other structures, and since no more space is available for its expansion, the natural recourse is to form internal folds to provide an increased area for its epithelium which has now become flattened and consists of small squarish cells with finely grained cytoplasm (Text-fig. 20 *a*). Soon, however, a further differentiation occurs in that the cells become vacuolated. These vacuoles are present mostly in those parts of the cells which face the lumen of the

kidney ; and, therefore, the cytoplasm and the nuclei move towards the outer ends.

Further changes that occur in the kidney during its subsequent development are chiefly concerned with the structure of its walls, the relative position of the various organs in relation to the kidney remaining practically the same. The internal folds become deeper and the mesenchyme cells migrate into these folds and form their supporting tissue. The folds penetrate deeply into the interior of the kidney and thus only a small lumen is left which lies towards its right anterior end, where it opens, on the one hand, into the pericardium (through the reno-pericardial aperture) and, on the other, into the ureter.

With further development, there is an increase in the number and size of these folds accompanied by a branching of the folds to form secondary folds (Text-figs. 20 *b* and 25 *b*). These folds now anastomose and, consequently, the kidney presents the appearance of a lamellar gland. When the folds increase in height, the mesenchyme cells which have migrated into them, get pressed into sheet-like structures and thus the two walls of each fold are closely pressed against each other. Sinuses also appear within the folds at the time of their formation and these persist, and are connected with the blood-vessels of the kidney.

By the time the young snail hatches out of the egg, the kidney consists of repeatedly branching and anastomosing folds lined with a flat epithelium of vacuolated and glandular cells. In these cells concretions are now recognisable, which clearly show that the excretory activity of the kidney has already commenced.

As the kidney undergoes these changes, the ureter is not left unaffected, but gradually grows towards its anterior side and comes to lie dorsally to the kidney. Its posterior part which is connected with the kidney no longer remains a tubular structure, but its lumen becomes wider and, like the kidney, it also forms folds from its dorsal wall (Text-fig. 20 *b*). These folds arise almost simultaneously with the formation of the kidney-folds and increase in length till they meet the opposite wall and thus produce a lamellar structure. The cells, however, maintain their original shape and size, and never become vacuolated.

#### *The Left Rudimentary Kidney.*

The origin of the left kidney as a solid thickening on the left postero-ventral wall of the left pericardium has already been described. The rudiment of the left ureter arises as an evagination from the left inner wall of the mantle-cavity at a later stage, but it remains very small as compared with the ureter of the right side.

As the embryo grows, the development of both the left kidney and its ureter (effluent duct) proceeds so slowly as to give the impression of arrested growth. Text-fig. 16 *g* is a transverse section of the visceral-sac rudiment of an embryo in Stage 5, and passes through the rudiment of the left kidney which is still a solid thickened growth without any indication of an evagination. It lies close to the rudiment of the gonad. Fig. 20 *c* is a sagittal section of the visceral-sac rudiment of an embryo of the same stage, *i.e.*, Stage 5, which shows the rudiment of the left kidney and also a slight depression in the wall of the mantle-cavity

directed towards the left kidney rudiment. This depression is the rudiment of the left ureter.

As development proceeds, the middle of the left kidney-thickening evaginates and the kidney-cells become arranged round its narrow lumen in a single layer (Text-fig. 20 *d*). The lumen retains its communication with the pericardium through an aperture which can be described as the left reno-pericardial aperture. Meanwhile, the ureter rudiment deepens to form a small tubular left ureter which grows inwards and abuts against the blind end of the left kidney rudiment, but has not yet opened into it.

In an embryo in which complete torsion has taken place (Stage 10) the left kidney leaves its former ventral position and comes to lie dorsally. In a transverse section of the visceral-sac rudiment of an embryo in this stage it is seen that the original left kidney, after rotating through 180°, becomes the topographical right kidney. This kidney is now a small vesicular structure opening into the pericardium through a small and narrow left reno-pericardial aperture (Text-fig. 22 *a*) and lies at the right dorsal end of the spacious pericardium. The left ureter has already opened into it and is a long tube with a narrow lumen.

The morphologically left rudimentary kidney and its ureter are closely connected with the genital organs of the animal and so their further fate is discussed along with the development of the reproductive organs. We may note here that this kidney and its ureter persist in *Pila*, but do not function as excretory organs— they function together as the genital duct.

Thus, a close study of the development of the left kidney clearly establishes the fact that it does not “disappear at an early stage” in *Pila*, as stated by Fernando<sup>1</sup> (1931), but that it persists and is closely connected with the development of the reproductive organs.

*Previous work and discussion.*— Numerous accounts of the structure and relations of the Gastropodan kidneys have been written, especially by authors who were interested either in the relationship of the two kidneys in the Diotocardia or in the homology of the single Monotocardian Kidney with either one or the other of the Diotocardia. These accounts are chiefly based on comparative anatomical work and contain a large number of contradictory statements. Three views have been propounded; one set of workers maintain that the single kidney of the Monotocardia is homologous with the left kidney of the Diotocardia (Pelsencer, Lang and Herschler); the second set hold the opposite view, i.e., the Monotocardian Kidney is homologous with the right kidney of Diotocardia (Haller, 1886; Randles, 1905; etc.); while the third view is that the Monotocardian kidney is homologous with both the kidneys of the Diotocardia (Perrier, 1889; Woodward, 1901). Erlanger (1891) was the first to prove, by a study of the development of *Paludina*, that the single kidney of *Paludina* (which is in reality the

<sup>1</sup> Fernando (1931) is not very clear in his description of the left kidney. He simply states that the rudiment of the left kidney arises as an evagination from the left pericardium below the intestine, but in his fig. 4, Pl. I, he represents it as a thickened growth rather than as an evagination. Fernando's further statement that the left kidney disappears “without coming in contact with the mantle-cavity”, is not supported by the development of *Pila globosa*.

morphological right, though topographically the left, kidney in the adult) corresponds to the left kidney of the Diotocardia. He showed that a rudimentary morphologically left kidney makes its appearance, to disappear later. But Drummond (1903) and Otto and Tönniges (1905) showed that the rudimentary morphologically left kidney does not disappear as Erlanger had thought, but persists and subsequently comes to lie on the right side of the pericardium after undergoing a complete rotation through  $180^\circ$  and becomes connected with the genital system of the animal.

I do not wish to enter into a discussion of the relationship of the two kidneys in the Diotocardia and their homology with the single kidney of the Monotocardia, as this point has already been exhaustively dealt with both by Otto and Tönniges (1905) and Sachwatkin (1920), who, after a survey of all the evidence, reached the conclusion that the kidney of the Monotocardia, whether it consists of a single or a double chamber, is homologous with the left kidney of the Diotocardia. Fernando (1931), on the basis of the development of this organ in *Ampullaria* (*Pila*) *gigas*, supports this view. My own investigations, while confirming the conclusions of Fernando, have also revealed the fact that the morphologically left rudimentary kidney does not disappear, as stated by Fernando, but that it persists, as in the case of *Paludina* (Otto and Tönniges 1905), and becomes intimately connected with the genital system of the animal.

Prashad (1925), after giving a brief summary of the earlier works on the kidney of Ampullariidae, describes that "the renal-organ of *Pila globosa*, as of all Ampullariidae, consists of two chambers (i) a right anterior, and (ii) a left posterior, which lies somewhat to the left of and posterior to the anterior chamber. These two parts, though they are homologous with the two chambers in other Taenioglossa, are not similar in structure to that of any form in which the renal organ has been properly investigated". On account of this difference in structure, Prashad refers to them "by the non-committal names of the anterior and the posterior renal chambers". A study of the development of the kidney in *Pila globosa* proves, as has been described by Fernando (1931), that the "Kidney" is the homologue of the "posterior renal chamber" of Prashad in the adult animal, and that his "anterior renal chamber" corresponds to the "ureter". Thus, it is evident that the so-called anterior and posterior renal chambers are quite distinct structures of separate origin—the posterior renal chamber or true kidney is mesodermal in origin, while the anterior renal chamber is ectodermal in origin and constitutes the ureter. Agreeing with Fernando, I have preferred to describe it as the ureter because of its great resemblance to the ureter of *Paludina* and also because of its ectodermal origin.

Prashad (1925) writes: "The mode of excretion in *P. globosa* and other Ampullariidae appears to be similar to that in other Prosobranchs, except that probably both the chambers in this family have an excretory function, and the posterior is not of the nature of a nephridial gland. Owing to the single external opening, excretory products from the posterior chamber are also collected together and poured into the anterior chamber whence they are discharged into the mantle-cavity."

This statement is incorrect because it is only the posterior chamber which is glandular and has a vacuolated epithelium containing excretory granules, while no excretory matter is ever seen stored up within the non-vacuolated cells of the "anterior renal chamber" which corresponds to the ureter and is non-glandular. The ureter, in fact, corresponds to the similar structure in *Paludina*, and simply collects the waste products excreted by the glandular kidney and conveys them to be discharged into the mantle-cavity.

Finally, I must add a few words about the structure of the kidney itself. Haller (1886), Pelseneer (1896) and Randles (1905) describe the Prosobranch kidney as an acinose gland, and that it is the cavities of the acini constituting it which unite with each other and give rise to the principal branches which lead into the urinary chamber. In contrast to this, Perrier (1889) after making a comparative anatomical study of the Prosobranch kidney in different forms, arrived at the conclusion that the kidney consists of a sac-like structure which is divided by a large number of trabeculae lined with glandular cells. Erlanger (1891), after tracing out the full development of the kidney in *Paludina*, confirms the view of Perrier; and my own observations outlined in the preceding pages fully corroborate the fact that the walls of the simple sac-like kidney, which like that of *Paludina* can be compared to the simple kidney of *Haliotis*, become folded inwards, and that from these folds secondary folds arise which, on further development, increase in number and after anastomosing with one another give the adult kidney a lamellar or spongy appearance.

#### D. *The Pericardium, the Heart and the Blood-Vessels.*

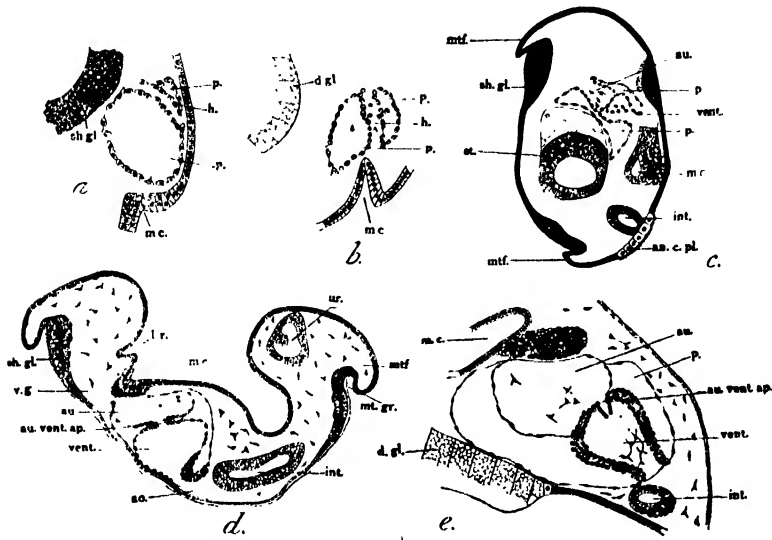
##### *The Pericardium and the Heart.*

I have already described that the heart first appears as a thickening of the posterior wall of the pericardium just above the right kidney.<sup>1</sup> This thickening develops into a knob-like growth consisting of more or less loosely arranged cells which projects into the cavity of the pericardium. On further growth the thickening forms a small invagination into the pericardial cavity and thus the original knob-like rudiment of the heart develops into a small pouch which hangs down into the cavity of the pericardium and is now lined by a single layer of cells.

With further development, the invaginated pouch reaches the opposite wall of the pericardium with which it joins and fuses. During this period, this rudiment of the heart remains confined to the dorsal part of the pericardium and stretches obliquely across it. In a longitudinal section, the heart appears as a straight tube. Text-fig. 21 *a* is a transverse section of an embryo in Stage 5 in which the heart is seen stretching obliquely across the dorsal part of the pericardium in

<sup>1</sup> Fernando (1931) describes the heart at a much later stage. He does not mention as to how or where it originates, but simply states that it "begins to be differentiated within the pericardium". From his description (he has not shown the heart in his figures) it is clear that it is a comparatively late stage in which the heart rudiment has already differentiated into the auricle and the ventricle.

the form of a small, narrow, undifferentiated tubular structure, the lumen of which communicates at both ends with the body-cavity of the embryo.



TEXT-FIG. 21. Stages in the development of the heart and the pericardium.

*a.* Transverse section of an embryo in Stage 5, passing through the pericardium and showing the heart rudiment:  $\times 223$ ; *b.* Sagittal section of an embryo in Stage 6, passing through the pericardium and showing the heart rudiment:  $\times 223$ ; *c.* Transverse section of an embryo in Stage 7, showing the differentiation of the auricle and the ventricle:  $\times 133$ ; *d.* Transverse section of an embryo in Stage 10, passing through the auriculo-ventricular aperture:  $\times 127$ ; *e.* Sagittal section through the pericardium of an embryo in Stage 11, showing the auriculo-ventricular aperture:  $\times 132$ .

At a slightly later stage, the pericardium has increased further in dimensions, and at about the middle of its extent it occupies the entire space between the anterior part of the intestine and the body-wall. Almost in the middle of the tubular heart there appears a thickening which, a little later, develops into a circular constriction gradually dividing the heart into two parts. These two parts develop later into the auricle and the ventricle. Text-fig. 21 *b* is a sagittal section of an embryo in which the pericardium has grown antero-dorsally on the right side of the intestine, and the heart, still situated within its postero-dorsal part, lies to the right of the reno-pericardial aperture. The section shows the thickening of the wall of the heart, which later forms the annular constriction.

In the next stage (Stage 8), a further differentiation of the heart has taken place—it is no longer tubular in shape but has broadened at the region of the constriction. Text-fig. 21 *c* is a transverse section of an embryo in which the pericardium has considerably increased in dimensions and has completely shifted upwards to lie dorsally across the junction of the intestine and the stomach; within the pericardium, the auricular and the ventricular parts of the heart are well differentiated. They are broad at their junction with each other at the constriction, but become narrow towards their outer ends.

Being no longer hampered by the limited space between the gastro-intestinal wall and the body-wall, the pericardium develops into a very wide thin-walled chamber extending almost in all directions. It is bounded on its ventral side by the gastro-intestinal wall, on its anterior and left side by the everted shell-gland, on its right by the body-wall, and posteriorly by the kidney.

As torsion proceeds, the pericardium follows suit, so that by the time torsion is completed, the pericardium, along with the heart contained in it, shifts downwards towards the left side in the visceral mass. Text-fig. 21 *d* is a transverse section of an embryo in which complete torsion has just taken place (Stage 10). At this stage the pericardium is a very wide sac but has an extremely thin wall with flattened cells; it extends anteriorly as far as the digestive-gland, while posteriorly and on the right, it is bounded by the kidney. The posterior limit of the pericardium is almost in the same plane as the anterior end of the origin of the rudiments of the gill-filaments. The pericardium is broader dorsally and, due to lack of space, narrows gradually towards its ventral end. The heart, which has grown considerably in size, still lies obliquely in the posterior part of the pericardium. The auricle is a thin-walled bag full of blood and its wall is lined with flattened cells connected with one another only through their drawn out ends. The ventricle, which is elongated dorso-ventrally and lies in an obliquely antero-posterior direction, is a pear-shaped structure whose cells lie close together and are not flattened, thus forming a thicker wall than that of the auricle. Its upper part which communicates with the auricle is broader, while it tapers towards its ventral end which lies against the intestinal loop to open into the aorta. The auricle and the ventricle have separated almost completely from each other by the deepening of the constriction, although they communicate with each other through the narrow auriculo-ventricular aperture. It is difficult to give the exact outlines of the heart and the pericardium, as these vary greatly due to systole and diastole, and are also greatly affected by the fixatives used.

The pericardium and the heart now lie in their definitive positions on the left side of the visceral sac, so that the heart, which became differentiated from the wall of the pericardium when the latter lay on the right side of the intestine, has rotated to the right through 180° and now lies at its adult definitive position on the left side.

In the next stage (Stage 11), the pericardium has still further increased in size, and the muscle-fibre-forming cells have already developed and can be easily distinguished from the endothelial cells of the ventricle, the ventricular walls having become much thicker. Text-fig. 21 *e* is a sagittal section of an embryo in which the muscle-fibres are already laid, the auriculo-ventricular aperture has considerably narrowed and is protected by two septa which will develop later into valves. These rudimentary septa are here seen hanging into the ventricular chamber, a condition which is met with in the adult stage. They are arranged in such a manner that, on the contraction of the ventricle, the blood cannot flow back from the ventricle into the auricle. This is so on account of the closure of the auriculo-ventricular aperture

by these septa, which act as rudimentary valves. The blood is thus propelled only into the aorta.

Among Gastropods three types of development of the heart and the pericardium have been described. These are: (1) In the first type, comprising the majority of forms, the differentiation of the pericardium takes place first, and the rudiment of the heart appears in its wall afterwards. *i.e.*, it follows the same course as has been described above in *Pila globosa*. (2) In the second type the reverse is the case, *i.e.*, the heart arises first, and is followed by the differentiation of the pericardium. (3) In the third type the pericardium and the heart arise almost simultaneously.

#### *The Blood-Vessels.*

The origin and development of the blood-vessels in *Pila globosa* is similar to that described in other Gastropoda, such as *Paludina* (Erlanger, 1891). I shall not, therefore, give a detailed account of it.

The blood-vessels arise quite independently of the heart. They arise in the form of intercellular spaces or sinuses of indefinite shape and size in between the mesenchyme cells lying scattered within the body-cavity. These sinuses appear in a very early (Stage 1) and are situated at different regions of the body. They are surrounded by flattened mesenchyme cells without any definite walls. One such large sinus is present at the anterior end of the embryo just beneath the stomodaeum, while another is present at the base of the foot beneath the primitive stomach, and similarly there are others in other parts of the body. These have been described by some authors as being capable of pulsating even before the differentiation of the heart (as in *Paludina*), but in *Pila* no such pulsations can be seen in its early stages owing to the opacity of the embryo. The presence of sinuses in the early stages can be made out only on cutting sections, but in later stages, when the food-yolk has been absorbed and the embryos become more or less transparent, these sinuses can be easily made out not only in the living condition but even in the whole mounts after fixation. In the former case they are transparent; in the latter they take a lighter stain than the other parts of the body.

There is one remarkable fact noticed with regard to the position of these sinuses, *viz.*, that they arise exactly at those places where later on (as seen in the adult) the blood-vessels are formed. As development proceeds, these scattered primary sinuses enclosing the primary body-cavity, in contrast to the heart which represents the secondary coelom, become narrower and narrower, until finally they join each other and form blood-vessels. The vessel which joins the open end of the ventricular part of the heart gives rise to the aorta. In Text-fig. 23 c, which represents a transverse section passing through an embryo in Stage 11, the aorta is seen arising from the ventricle. The veins (the pulmonary, the efferent cteneidial and the efferent renal) arise much later than the aorta, and open dorsally into the auricle. Of these, the efferent cteneidial vein differentiates first and is formed from sinuses in the mantle, especially those at the base of the gill-leaflets, when the latter are differentiated on the future inner side of the mantle. These sinuses unite to open into the auricle.



*E. The Gonad and the Genital Duct.*

The origin of the gonad rudiment as a thickening of the roof of the pericardium at its extreme left end, situated dorsally to the left kidney rudiment, has been already described above. To begin with, it consists of a few cells only, but as development proceeds, the rudiment increases in thickness (Text-fig. 16 *g*) by a proliferation of cells next to the digestive-gland, the cells travelling ventral-wards and producing a cord of cells. Subsequently (Stage 6), as a result of torsion of the visceral-sac rudiment, the gonad rudiment is also transposed to the right side of the digestive gland, and comes to lie at the left inner end of the floor of the pericardium. Unlike the evagination of the kidney rudiment and the invagination of the heart rudiment, the gonad rudiment develops in the form of a solid cord of cells. But an important fact to be observed is that, inspite of the torsion, the gonad rudiment, retains its position next to the digestive gland throughout the course of its development.

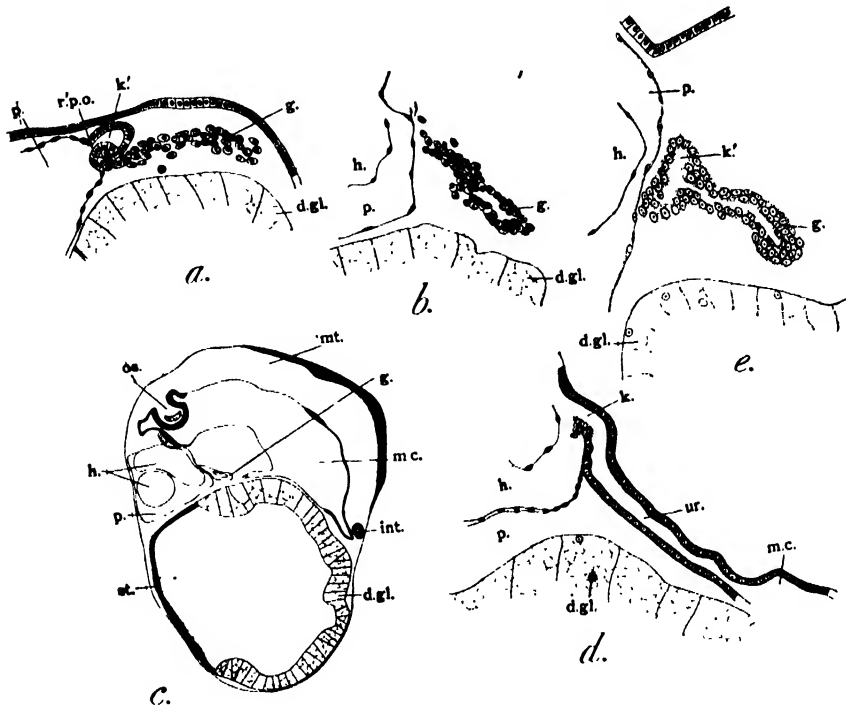
In early stages, the left kidney rudiment lies on the ventral side of the gonad rudiment, but when the pericardium shifts completely towards the right, the gonad comes to lie anteriorly to the left kidney rudiment, though close to it (Text-fig. 20 *c*). This proximity of the two rudiments is due to the narrowed lumen of the rudimentary left pericardial sac, between the left kidney and gonad rudiments.

As the visceral-sac rudiment undergoes a complete rotation (Stage 10), the pericardium along with the gonad and kidney rudiments, passes over to the left side of the visceral sac. Consequently, the kidney and the gonad rudiments come to lie on the extreme right of the pericardium, instead of their former ventral position. Besides, the relative positions of the gonad and the left kidney rudiment are reversed, the left kidney rudiment now lying dorsally to the gonad rudiment, although the two still lie close together. Text-fig. 22 *a* is a transverse section in which the gonad rudiment lies ventrally to the kidney rudiment, but is so close to it that a sharp line of demarcation between the two cannot be drawn. It should be noted here that the left kidney rudiment never becomes differentiated to form a functional kidney but is incorporated into the gonad into which it is assimilated.

At the next stage of development (Stage 11), the distal end of the gonad rudiment lying close to the digestive gland develops a cavity within itself, while its proximal part lying beside the kidney still remains solid (Text-fig. 22 *b*); and the kidney itself communicates with the pericardium through the narrow left reno-pericardial aperture. Text-fig. 22 *c* is a transverse section of the visceral sac representing the position of the gonad rudiment (shown magnified in text-fig. 22 *b*) in relation to the other organs; while Text-fig. 22 *d*, is a semi-diagrammatic representation of the left ureter of the rudimentary kidney of the same embryo, showing its opening into the latter at its inner end, and into the mantle-cavity at its outer end.

As development proceeds, the gonad rudiment becomes hollow throughout its length, that is to say, the cavity which started first at its distal end now extends right upto its proximal end. This cavity however, does not communicate with that of the rudimentary left kidney.

Hereafter (Stage 12), the gonad rudiment develops rapidly. Proximally, the root of the gonad merges completely into the left kidney rudi-



TEXT-FIG. 22. Stages in the development of the gonad and the ureter.

a. Transverse section of an embryo in Stage 10, passing through the left rudimentary kidney, the left reno-pericardial aperture and the gonad:  $\times 264$ ; b. Transverse section of an embryo in Stage 11, passing through the gonad and showing the formation of the cavity at its distal end:  $\times 260$ ; c. Transverse section of the same embryo as in (b), showing the relation of the gonad with the other organs of the body:  $\times 46$ ; d. Diagrammatic representation of the left ureter opening into the left kidney and the mantle-cavity, in a transverse section of the embryo in Stage 11:  $\times 260$ ; e. Transverse section of the embryo in Stage 12, showing the gonad communicating with the left rudimentary kidney:  $\times 200$ .

ment, with the result that its cavity now communicates with that of this kidney, and, through it, with that of the mantle-cavity via the ureter of the left kidney; i.e., the left ureter becomes transformed into the genital duct of the adult. Distally the gonad forms a bend along with that of the digestive-gland. At this stage of development as well as in later stages, I could not observe the reno-pericardial aperture of the rudimentary kidney, and believe that it has disappeared.

By this time all the essential relations between the various parts of the reproductive system are fully established, and further development consists only of the differentiation of this gonad rudiment into either the male or the female genital organs. I have not, however, followed this differentiation.

*Discussion.* It is evident from the foregoing account that in *Pila*, as in *Paludina* (Erlanger, 1891; Drummond, 1903; Otto and Tönniges, 1905), the gonad rudiment and the rudimentary left kidney with its

ureter are closely connected with each other, and that this rudimentary kidney, after fusing completely with the developing gonad rudiment, takes part, along with its ureter, in the formation of the genital duct. The latter is, therefore, not an independent formation.

Fernando (1931) says that "the genital organs (with which the morphologically left kidney of the embryo is associated in *Viniparus*) do not develop in the embryos of *Ampullaria gigas*, till after they are hatched, so that it is possible that the genital duct may be a new formation. Further, no opening into the mantle-cavity was observed in connection with the morphological left kidney". But, it is clear from my observations that Fernando's conclusions are incorrect. He seems to have overlooked the early stages of the gonad rudiment, and, surprisingly enough, missed it even in the later stages, where it is quite a distinct structure, especially in his Stages 9 and 10, when the torsion is complete, and the embryo has a snail-like appearance.

#### F. The Respiratory Organs.

*Pila globosa* is a fresh-water form, but is also adapted to a terrestrial mode of life. In water, respiration is carried on by means of its ctenidium or gill, while on land, aërial respiration comes into play through its pulmonary sac or lung.

Brooks and McGlone (1908) have given a detailed and lucid account of the development of the respiratory organs of *Ampullaria* (*Pila*) *depressa*. My own observations on *Pila globosa* are almost in complete agreement with theirs as regards the origin and development of these organs, except for a few differences in minor details in the case of the lung. I consider it unnecessary, therefore, to describe the development of these organs in detail and give here only a brief summary of my observations.

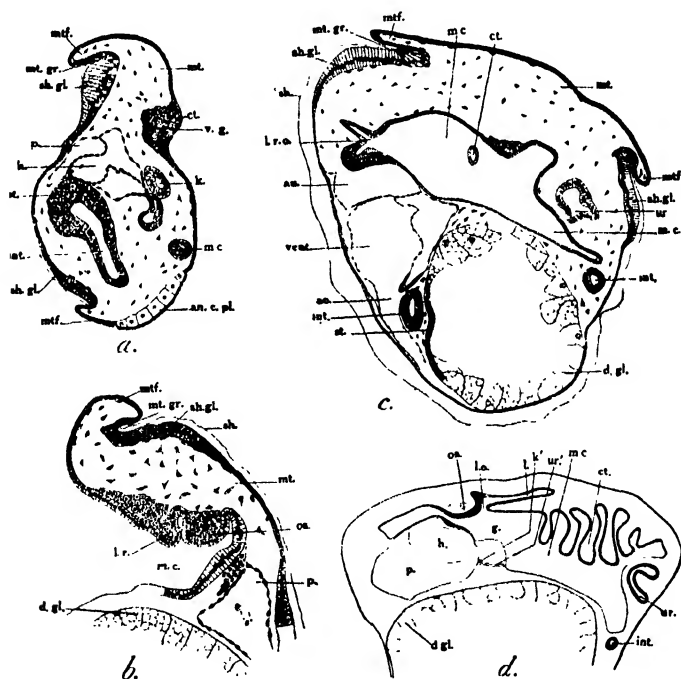
#### The Gill.

The first traces of the gill rudiment are discerned in Stage 8. Text-fig. 23a is a transverse section (passing through the pericardium and the gastro-intestinal junction) in which the epithelium on the right side is clearly thickened and its cells have become tall and columnar. This thickening is the first formation of the gill rudiment, which lies just dorsally to the concave thickening from which the visceral ganglion is delaminated in earlier stages, but which is now composed of a single layer of tall columnar cells. Text-fig. 23b is a horizontal section of an embryo in Stage 9, which shows three thickenings or ridges developed from the inner wall of the mantle. Two of these thickenings are separated from the third which lies to their left, by an infolding of the mantle-epithelium.<sup>1</sup> This infolding is the rudiment of the pulmonary sac, while the two thickenings on its right are the rudiments of the gill, and the one on its left is the rudiment of the osphradium. The rudiments of the gill and osphradium are thus seen as parallel ridges and fully confirm the statement of Brooks and McGlone (1908) that "the gill, the lung

<sup>1</sup> Text-fig. 23b, unlike other figures of sections, has been drawn in such a way that the left side of the figure is in reality the right side of the embryo, and *vice-versa*.

and the osphradium of *Ampullaria* arise simultaneously or nearly so in the embryo ”.

As development proceeds, other thickenings and outpushings representing further rudiments of the gill-filaments arise along the inner dorso-lateral surface of the mantle. Text-fig. 19*b* is a transverse section passing through the gill rudiments of an embryo in which torsion has already been completed and the first rudiments of the eyes have also appeared (Stage 10). The part of the mantle lying dorsally to the pericardium in the preceding stages (Text-fig. 23*a*) has now become dorso-lateral in position, after passing over to the left side of the embryo. Consequently, the rudiments of the gill-filaments, six to eight in number, now lie on the left side and project from the inner wall of the mantle-(Text-fig. 19*b*) into the mantle-cavity. On examining a series of consecutive sections (Text-figs. 19*a, b*), one finds that the ectodermal thickening, from which the visceral ganglion had originated, now lies at the extreme left of the mantle-cavity, just dorsally to the pericardium, and that the gill rudiments lie posteriorly but dorsally to this ectodermal thickening.



TEXT-FIG. 23. Stages in the development of the gill and the lung.

*a.* Transverse section of the visceral-sac rudiment of an embryo in Stage 8, passing through the thickening of the gill rudiment:  $\times 127$ ; *b.* Horizontal section of an embryo in Stage 9, showing the differentiation of the rudiments of the gill-lung and the osphradium:  $\times 157$ ; *c.* Transverse section of an embryo in Stage 11, passing through the opening of the lung into the mantle-cavity.  $\times 90$ ; *d.* Transverse section of an embryo in Stage 11, passing through the opening of the lung into the mantle-cavity;  $\times 65$ .

The rudiments of the gill-filaments first appear as solid outpushings of the epithelial wall completely filled up with compact masses of the

subjacent mesenchyme cells. As development proceeds, these rudiments increase in size, and the mesenchyme mass in each rudiment is detached from the outer epithelium and forms a band-like structure in the middle of each filament. Very soon, however, these mesenchyme bands break up into loose cells in the older filaments (Text-fig. 19c). Each gill-filament thus becomes a long tubular structure with mesenchyme cells lying scattered in its cavity. The row of filaments is attached to the wall of the mantle which forms its ctenidial axis. Each filament consists of a double wall of epithelium composed of cubical cells, each with a rounded nucleus and a distinct nucleolus; the cells are ciliated on their outer surfaces. The elongated space enclosed between the two walls of each filament is traversed here and there by scattered mesenchyme cells, which later develop into muscle-fibrils. These fibrils run transversely across the filament and form a series of septa dividing the space between the two walls into smaller spaces called "lacunae", which communicate with one another and also with the pulmonary sinus, the origin and development of which has been described by Brooks and McGlone (1908).

The gill-filaments continue to increase in size as well as in number, so that, by the time the embryo hatches out, the number of these filaments reaches as many as 35 to 45 in each gill. Moreover, all the lamellae (filaments) are not of equal size, the largest lamellae being in the middle, and their size gradually decreasing towards the two ends.

Like other Pectinibranchiates, *Pila* possesses only one gill which is topographically the left, but morphologically the right. In spite of careful observations, I have never been able to find any trace either of a rudimentary left ctenidium or of a second row of filaments even in the very early stages of its development.

According to Lankester, the primitive gill of Mollusca was a ctenidium—a stalk with plates very much like the gills of *Chiton* and *Fissurella*. Spengel derives the prosobranch gill from the gill of some primitive form like *Chiton*, and according to him, the present form of the prosobranch gill is formed by a gradual coalescence of the free distal portion of the gill with the mantle-wall. The embryological history of the gill in *Pila* does not confirm the hypothesis of Spengel. The course of development throughout the Pectinibranchiata (Monotocardia) is similar to what I have found in *Pila*. Therefore, in the words of Osborn (1886), "it does not seem safe to accept the conclusions of Spengel and Lankester, that the Ctenobranch (= Monotocardian) gill is derived from a feather-form gill, like that of *Fissurella*, by the fusion of one side with the body-wall".

### *The Lung.*

The lung, as has already been pointed out, arises as an infolding of the mantle epithelium almost simultaneously with the formation of the gill and osphradial rudiments. Text-fig. 23b is a horizontal section passing through the gill and osphradial rudiments, between which lies the lung rudiment, a position which is maintained to the last. Text-fig. 21d is a transverse section of an embryo in Stage 10, passing through the lung rudiment which appears as an invagination, lying a little posteriorly to and to the right of the osphradial rudiment. This lung rudiment is well marked in Text-fig. 19a which is a transverse section of a slightly older embryo.

In the next stage (Stage 11), the lung rudiment becomes further invaginated into the substance of the mantle, just posteriorly to the

osphradium (Text-fig. 23c). Brooks and McGlone's description of this stage agrees with mine, but I find that in their fig. 13, Pl. 4, and fig. 14, Pl. 5, they wrongly label as lung rudiment the thickened epithelium which surrounds the extreme left end of the mantle-cavity, and from which the gill rudiments and the visceral ganglion have already arisen. The actual lung rudiment lies a little anteriorly (Text-fig. 23c), and occurs in the anterior sections of the same series, the posterior sections (Text-fig. 19c) of which show the condition exactly comparable to the diagrams of Brooks and McGlone in which they have misinterpreted the part of the mantle-cavity as the lung-groove.

Similarly, Brooks and McGlone have missed the lung rudiment in their fig. 11, Pl. 3, and fig. 12, Pl. 4. In these two figures, they have indicated the posterior part of the mantle-cavity as the lung rudiment. It is a mistake which is quite natural if the part of the mantle-cavity labelled as "l.g." in figs. 13 and 14 be accepted as the lung-groove.

Text-fig. 23d is a transverse section of an embryo which is slightly older. It passes through the lung-opening as well as through the lung itself, and shows the latter as a flat, elliptical structure, dorso-lateral in position. From this stage onwards, right up to the hatching stage, the position and structure of the lung in *Pila globosa* completely agrees with that given in figs. 15, 16 and 17 and 18 of Pls. 5, 6 and 7 respectively of Brooks and McGlone in *Ampullaria depressa*. The lung having grown larger, now occupies a considerable space within the substance of the mantle, and only two very thin layers of connective tissue separate it from the inner and the outer epithelia of the mantle.

In later stages the dorsal epithelium of the head-vesicle forming the floor of the mantle-cavity becomes raised into a fold-like valvular structure, known as the epitaenia, which acts like an incomplete septum and divides the mantle-cavity into two incomplete chambers of unequal size. The smaller chamber lies towards the right, and is known as the branchial chamber, as it contains the gill, while the left is the spacious pulmonary chamber and contains the opening of the lung and the osphradium.

According to Brooks and McGlone (1908) "the lung of *Ampullaria* becomes functional before the gill does; for, the newly hatched young die very quickly if they are prevented from leaving the water while the adults survive a long immersion". I also found that the newly hatched young, lying in open glass dishes containing moist earth and a little water, crawled out of the dishes probably in quest of food, but after moving a few feet, shut themselves up within their shells and remained so for a considerable time (6 to 10 hours), and were found to be alive when brought back to water.

*Previous work and discussion.* Prashad (1925) considers the lung as a new structure or only a part of the second ctenidium which, in response to aerial respiration, has been developed in close association with the gill and the osphradium as a specially modified structure". *Pila* belongs to the family *Pilidae* (=Ampullariidae) which is the only family of Streptoneura in which the gill is present simultaneously with the lung. The Pectinibranchiata (Monotocardia), to which the family *Pilidae* belongs, are characterised by having a single ctenidium, and

no trace of a second gill, even in a rudimentary form, is found throughout the course of development. Therefore, from a study of the development of the lung in *Pila globosa*, I arrive at the conclusion that it is a new structure altogether which has developed by the modification of the mantle, and that it is not at all a modification of a second ctenidium.

Unfortunately little work has been done on the origin and development of this organ in other Gastropoda, and the little that is known concerns only the Pulmonata. While there is some unanimity concerning the origin of the lung in the terrestrial Pulmonates (Stylommatophora), in the case of the aquatic Pulmonates (Basommatophora) opinions differ. The lung arises after the formation of the mantle-folds and the mantle-cavity, and is considered as a derivative of the latter, as in *Lymnaea*, (Wolfson, 1880) and *Planorbis* (Rabl, 1879). Fol (1880), on the other hand, does not agree with this view, and believes not only in the independent or separate origin of the lung-cavity, but even in its earlier formation, for he says: "the mantle-cavity is only a secondary invagination and should not be confused with the pallial-cavity", i.e., the lung-cavity. Though Lankester (1874) believes in an independent origin of the lung-cavity, yet he agrees with Rabl (1879) and Wolfson (1880) in its secondary formation, that is to say, that the lung-cavity arises when the mantle-folds have already been formed. Again, all the four authors do not agree on the manner of its origin. Lankester describes (in *Lymnaea*) the lung as a simple depression arising on the right side, hidden below the overhanging mantle-lobes, when the latter are already covering a considerable part of the body. Rabl (1879), on the other hand, describes in *Planorbis* that as the mantle grows further, its growth takes place more on the right than on the left side. Soon a shallow indentation takes place on the right side, which soon deepens and forms the rudiment of the respiratory cavity.

Wolfson (1880) gives an altogether different origin of the respiratory cavity in *Lymnaea*. It arises "by the fusion of the right margin of the mantle which extends more on the right than on the left side with the body-integument, only a small aperture, the respiratory aperture, being left which leads into a deeply widening part of the mantle-cavity—the lung-cavity". Thus the lung-cavity is shown to be a transformed mantle-cavity.

In the Stylommatophora, on the other hand, we find that the lung-cavity arises quite independently of the formation of the mantle-fold or the mantle-cavity, as in *Helix* (Fol, 1880), *Limax* (Meisenheimer, 1898) and *Arion* (Heyder, 1909). Not only this, but Heyder has also stated that in *Arion* the lung arises as an ectodermal invagination even before the presence of any trace of either a mantle-cavity or a mantle-fold. Heyder has traced the complete development of the lung-cavity in *Arion* and has found that it originates as an altogether separate structure from the mantle-cavity which is a secondary formation. Other authors have described it as an ectodermal invagination arising almost simultaneously with the mantle-cavity, but according to Heyder they have either "overlooked the first invagination of the lung or failed to recognise its significance, and have noticed it together with the mantle-cavity appearing a little later".

From the above review of the origin of the lung amongst the different forms both of the Basommatophores and the Stylommatophores, one is led to the conclusion that the lung has two different kinds of origin amongst the Plumonata, *i.e.*, while it arises separately in the case of Stylommatophores (*e.g.*, *Arion*), in the Basommatophores on the other hand it is a derivative of the mantle-cavity and is thus a secondary formation.

When we compare the lung in *Pila* with that of the Pulmonata, we find that the two can hardly be considered as homologous structures, because in the former case it is a secondary formation and at the same time arises as an indentation of the mantle itself; in the latter case, however, especially in the Stylommatophora (*e.g.*, *Arion*), where it has been thoroughly studied, the lung is a primary formation and develops ontogenetically before the mantle-cavity.

### G. The Nervous System.<sup>1</sup>

The earliest rudiments of the nervous system appear at an early stage when the embryo is still bilaterally symmetrical externally, although internally it is asymmetrical, because of the unequal growth of the pericardial rudiments and the opening of the anus on the left ventral side. The rudiment of the mantle-cavity is as yet mid-ventral in position and the shell-gland is situated on the aboral dorsal surface (Stage 3). The head plates become thickened and many-layered near their extreme anterior ends, and some of the cells lying innermost project inwards from the thickened region. These delaminating cells of the ectodermal plates form the first rudiments of the cerebral ganglia (Text-figs. 24*a*, *b*) which are thus the first ganglia to be formed.

As development proceeds, more cells are delaminated from the head plates and we get thin sheets of closely arranged cells pressed against the inner surfaces of these plates. These cells closely resemble the mesenchyme cells and it is extremely difficult, at this stage, to differentiate the ganglion cells from the adjacent mesenchyme cells.

The rudiments of the pedal ganglia (Text-figs. 24*c*, *d*) are the next to be formed, one on each side, in an embryo slightly older than Stage 3. At this stage the embryo is asymmetrical even externally, the shell-gland having passed over more or less to the left side (Text-fig. 4*d*). The lateral walls of the foot which, to begin with, consist of a single layer of tall columnar cells become thickened and appear many-layered at about their middle regions. From these thickenings, cells are delaminated in the same manner as in the case of the cerebral ganglia, and are laid against the inner surfaces of the walls of the foot on each side. Text-fig. 24*c* is a transverse section of an embryo in Stage 4, and passes through the rudiments of the pedal ganglia which lie more or less posteriorly to the cerebral ganglia.

Almost simultaneously with the appearance of the rudiments of the pedal ganglia, two other similar thickenings appear, one on each side, in the lateral walls of the "Kopffuss". They are situated immediately

<sup>1</sup> In the following account the terminology used for the various ganglia and their connections (commissures and connectives) is that proposed by Spengel (1881) and adopted by Prashad (1925).





below the velum at a level higher than and posterior to that of the rudiments of the pedal ganglia, and constitute the first rudiments of the pleural ganglia.

In the next stage in which the first rudiment of the radular sac is already evident (Stage 6), a number of cells are laid on either side of the junction of the rudiment of the radular sac with the oesophagus. These cells arise from the columnar cells lining the walls of the fore-gut, and are thus ectodermal in origin. They are the rudiments of the buccal ganglia. Unfortunately, I have not been successful in obtaining sections in which the cells of these rudiments can be observed in a delaminating state; in my sections the cells are already laid against their place of origin. By the time of the appearance of these rudiments of the buccal ganglia, the cerebral, the pedal and the pleural ganglionic rudiments have not yet completely separated from their places of origin.

The first rudiments of the intestinal ganglia are differentiated about the same time as those of the buccal ganglia. Just before the differentiation of these rudiments, the ectodermal cells of the ventro-lateral surfaces of the body-wall, almost at the junction of the "Kopffuss" with the visceral-sac rudiment, become differentiated from those of the rest of the body-wall by becoming tall and columnar. On further development, these cells multiply and form two ectodermal thickenings, one on each side, in the region of the hinder end of the stomach (Text-fig. 24e). These thickenings are almost symmetrical in position and consist of more than one layer of cells. As development proceeds, cells are delaminated from the inner surfaces of these thickenings and form the first rudiments of the intestinal ganglia.

Of all the rudiments, that of the visceral ganglion is the last to appear, and is differentiated immediately after the origin of the intestinal ganglia. In an embryo in Stage 5, a part of the right wall of the visceral-sac rudiment, situated just posteriorly but dorsally to the level of the pericardium, which also lies on the right side, becomes differentiated by its constituent cells becoming tall and columnar. These cells soon proliferate and delaminate inwards a sheet of compact cells stretching lengthwise in an antero-posterior direction: this sheet of cells is the rudiment of the visceral ganglion which, unlike the rudiments of other ganglia, is single and unpaired (Text-fig. 24f).

Thus, by the time of the differentiation of the visceral ganglion, the rudiments of all the ganglia are laid. All these rudiments are ectodermal in origin and the delaminated cells forming these rudiments originate always from tall columnar cells. In the case of the cerebral, the buccal, the pedal, and the pleural ganglia, the cells are already columnar in shape, but in the case of the intestinal ganglia and the visceral ganglion, the cells are at first small and cubical, and become tall and columnar only at the time of the differentiation of these ganglia.

The rudiments of the different ganglia, even after their complete delamination, remain at first thickly pressed against their respective regions of origin, but can be easily distinguished, as the latter again become single-layered, and acquire a distinct outline.

The rudiments of the cerebral ganglia are the first to detach themselves completely from the head plates, while the rudiments of the pedal

and pleural ganglia are still attached to their respective places of origin. After being detached, the thin sheets of cells of the cerebral ganglia begin to thicken at about their middle on each side (Text-fig. 24*h*). When an increase in length takes place in the anterior part of the embryo, it appears as if the rudiments of the cerebral ganglia are being gradually pushed back, but in reality they maintain their position. They are as yet irregular in shape and consist simply of two masses of cells which, on account of their vertical position, lie parallel to each other and to the median axis. Soon, however, they extend along the inner side of the roof of the head-vesicle and become convexly arched and, at the same time, move slightly inwards.

The pedal and pleural ganglia have, meanwhile, become further differentiated, but from the time of their origin, the boundaries of these two ganglia cannot be marked off from each other, as the two form a common diffused mass of ganglion-cells. In transverse sections of the "Kopffuss", these ganglia appear as long thread-like structures placed against the lateral walls of the foot. The pedal ganglia lie at the anterior lower part of the foot, and when the latter flattens at its antero-ventral end, these rudiments come to lie nearer, at the junction of the basal and the lateral walls of the foot. The pleural ganglia grow just behind the pedal ganglia but a little dorsally to them. While in their early stages they lie along the lateral walls of the foot, in the later stages they appear to move away from these walls, and thus their longitudinal axes make acute angles with the median axis of the embryo. The pleural ganglia fusing with the pedal ganglia form the characteristic pleuro-pedal ganglionic masses, one on each side of the median line.

The rudiments of the buccal ganglia have, by this time, become compact masses of cells. They remain, however, at their original position and do not shift in any direction. They lie almost in the same transverse plane as the cerebral ganglia (Text-figs. 24*g*, *h*), while the pedal and pleural ganglia are situated more or less posteriorly.

During the course of development represented in the abovementioned stages, the rudiments of the intestinal ganglia still consist of a small number of cells which no longer occupy their original positions, but have shifted a great deal as a result of torsion. The left ganglion shifts inwards towards the median plane directed more or less towards the anterior end, while the right ganglion shifts upwards on the right side and lies a little posteriorly to the left one. Text-fig. 24*i* is a reconstruction from a few consecutive sections of an embryo and shows the positions of the two intestinal ganglia. The rudiment of the visceral ganglion still lies on the right wall of the visceral sac rudiment towards its dorsal side, and though it has completely separated from its place of origin on the body-wall, it has not yet receded into the interior.

The next stage of development to be described is an embryo (Stage 10) in which complete torsion has just taken place; the rudiments of the eyes and tentacles are already formed and the foot has flattened ventrally along its entire length. Some of the ganglia, *viz.*, the cerebral, pedal, pleural and intestinal, lie towards the interior at some distance away from the body-epithelium. These ganglia are now well differentiated, and fibrous cells (neurofibrils) are already formed within them.

Text-fig. 24j is a transverse section which shows the cerebral ganglia advancing dorsally towards the median line to meet each other at their anterior ends through a string of cells which constitutes the rudiment of the cerebral commissure. This rudiment is not shown in the figure as it lies in the sections immediately preceding it, where it is seen to arise from the inner surface of the anterior end of each ganglion to meet in the mid-dorsal line above the pharyngeal mass. The figure shows that each cerebral ganglion, while it is thickest in the middle especially opposite the rudiment of the tentacle, thins out at its two ends and thus appears, in a transverse section, triangular in shape with the apex of the triangle directed dorso-laterally. At this stage the cerebral ganglia extend posteriorly up to the region of the eye rudiments. The first rudiment of the cerebral commissure, which is well developed by now, is laid down in Stage 9. Some of the peripheral ganglion-cells from each ganglion advance towards the interior and are so arranged as to form rudimentary strings which proliferate and advance inwards, till finally the two rudimentary strings projecting from the opposite ganglia meet each other at about the median line of the embryo and thus give rise to a thin cord of cells, which on further development forms the cerebral commissure. No mesenchyme cells lying scattered within the body-cavity take part in the formation of this commissure. Similarly, a nerve arises from the outer or dorso-lateral part of each cerebral ganglion and advances towards the tentacle rudiment to form the tentacular nerve.

The buccal ganglia are well developed and are connected together through a buccal commissure, which lies behind the radular sac and beneath the oesophagus.

Text-fig. 24k is another transverse section of the same series passing through the pedal ganglia which now lie in the same vertical plane as the eye rudiments, and have moved inwards both from the lateral as well as the ventral walls of the foot. A delicate cord of the ganglion-cells, arising in the same way as the rudiment of the cerebral commissure, connects the inner dorsal ends of these ganglia and thus forms the rudiment of the first pedal commissure. Similarly another cord of cells lying below the first pedal commissure joins the inner ends of the antero-ventral regions of the pedal ganglia, and forms the rudiment of the second pedal commissure. A comparison of these commissures with the cerebral commissure at once convinces us that the latter originates much earlier than the former. Nerves arise both from the antero-ventral and the postero-ventral ends of the pedal ganglion on each side—the former are the anterior pedal nerves and run forward to supply the anterior part of the foot, while the latter represent the rudiments of the main trunks of the pedal nerves which extend right up to the posterior end of the foot. The pedal nerves arise from the antero-lateral sides of these main trunks.

The pleural ganglia (Text-fig. 24l), like the pedal, are well developed and are completely fused with the latter at their postero-dorsal surfaces. The pleural ganglia, however, can only be differentiated from the pedal by their relative positions as well as by the fact that the median axis of each pleural ganglion lies slightly to the outside of that of the pedal ganglion of the same side. Besides, the pleural ganglia are obliquely

placed and form acute angles with the median axis of the embryo. They taper posteriorly and continue as the connectives which join them with the intestinal ganglion and the visceral. The relative positions of the pleural and the pedal ganglia can be easily understood by a comparison of Text-figs. 24*k* and *l*. The statocysts are now closed vesicles, but they still lie dorsally and just posteriorly to the pleural ganglia.

The first rudiments of the cerebro-pedal connectives (Text-fig. 24*p*) are also laid down at this stage by the meeting together of the ganglion-cells which project both from the cerebral as well as from the pedal ganglia of the same side, and now form a delicate string of cells. Almost simultaneously with the formation of the rudiments of the cerebro-pedal connectives, another string of cells becomes differentiated and connects each cerebral ganglion at its postero-ventral end with the antero-dorsal end of each pleural ganglion; this forms the rudiment of the cerebro-pleural connective. Each cerebro-pleural connective lies postero-dorsally but almost parallel to the cerebro-pedal, the two connectives serving to differentiate the pedal and the pleural ganglia from each other.

As a result of complete torsion, the intestinal ganglia undergo a complete change of position; the morphologically right intestinal ganglion (*i.e.*, the ganglion on the right ventro-lateral side at the time of its differentiation) passes over to the left dorsal side and is now topographically the left, and is known as the supra-intestinal ganglion (Text-fig. 24*n*). The morphologically left intestinal ganglion now lies on the right ventral side and is, therefore, known as the infra- or sub-intestinal ganglion (Text-fig. 24*m*).

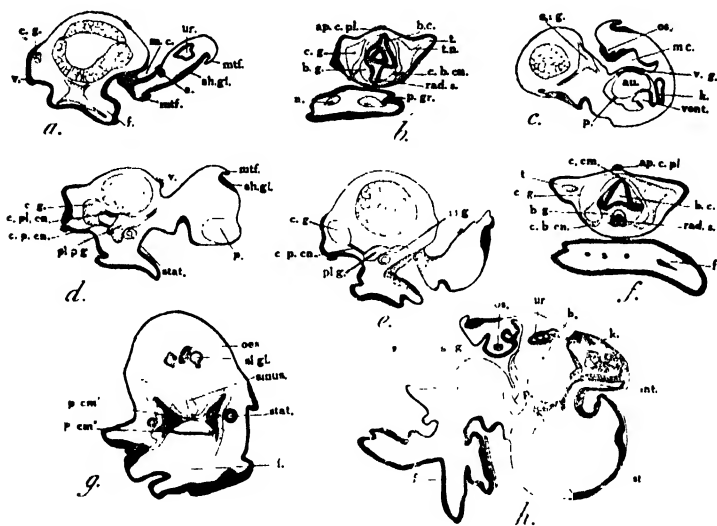
Similarly, as the dorsal part of the visceral sac (=mantle rudiment) comes to lie on the left side, the visceral ganglion, which was formerly on the right side and dorsal to the mantle-cavity, now comes to lie between the floor of the mantle-cavity at its extreme left and the roof of the pericardium (Text-fig. 24*o*). However, unlike the other ganglia, it does not recede into the interior, but remains closely applied to the wall of the mantle-cavity as a ribbon-like structure.

In the next stage of development (Stage 11), in which the rudiments of the eyes as closed vesicles have appeared, the various ganglia have developed further, and all the commissures and connectives have been laid down. The cerebral ganglia extend posteriorly, slightly beyond the eye rudiments, and the two ganglia are connected with each other anteriorly through another commissure running beneath the buccal mass, which is the rudiment of the labial commissure (Text-fig. 25*b*), that is quite slender as compared with the strong and band-shaped cerebral commissure. A nerve arising from the cerebral ganglion runs downwards and inwards and then curves upwards to join the buccal ganglion of its own side and its latero-ventral end. This is the rudiment of the cerebro-buccal connective which lies behind the plane of the cerebral commissure (Text-fig. 25*b*).

The cerebral ganglia have receded to their innermost limit and lie almost pressed against the buccal mass anteriorly. The tentacular nerves arising from the cerebral ganglia are well developed and run through the substance of the tentacles. The eye rudiments lie closely

pressed against the outer margins of the posterior part of the cerebral ganglia, but there is no indication as yet of the optic nerves.

The pedal ganglia develop further and approach each other closer than in the preceding stage. The first pedal commissure develops further and becomes band-shaped, but the second pedal commissure remains slender. Both the commissures are situated immediately behind the plane of the eye rudiments. The statocysts, which have shifted further downwards and inwards, now lie pressed against the outer margins of the pleural ganglia, immediately behind and more or less dorsally to the first pedal commissure. Text-figs. 25*c, d* represent sagittal section of an embryo of this stage (Text-fig. 5*d*) passing through the supra-intestinal ganglion and a part of its connective with the left pleural ganglion, and the cerebro-pedal and the cerebro-pleural connectives.



TEXT-FIG. 25. More stages in the development of the nervous system.

a. Sagittal section (right of the median line) of the same embryo as in Text-fig. 24*j* (Stage 10), showing the fusion of the pedal and pleural ganglia to form the pleuro-pedal ganglionic mass:  $\times 39$ ; b. Transverse section of the embryo in Stage 11, passing through the plane of the cerebro-buccal connectives, the labial commissure, and the tentacular nerve:  $\times 39$ ; c. Sagittal section (right of the median line) of an embryo in Stage 11, showing the fusion of the infra-intestinal ganglion with the pleuro-pedal ganglionic mass:  $\times 39$ ; d. Sagittal section (left of the median line) of an embryo in Stage 11, showing the cerebro-pedal and cerebro-pleural connectives, and a part of the supra-intestinal nerve meeting the pleural ganglion:  $\times 39$ ; e. Oblique sagittal section (left of the median line) of an embryo in Stage 11, passing through the supra-intestinal ganglion, and a part of the supra-intestinal nerve running downwards:  $\times 39$ ; f. Transverse section of an embryo in Stage 12, passing through the cerebral commissure, the cerebro-buccal connectives and the tentacular nerve:  $\times 39$ ; g. Transverse section of the same embryo as in (f), showing the first pedal commissure, the slender second pedal commissure, and the position of the statocysts:  $\times 39$ ; h. Sagittal section (left of the median line) of an embryo in Stage 12, showing the relative position of the supra-intestinal ganglion in relation to other organs. The section passes through the plane of the oesophradium, the heart, the kidney and the opening of the stomach into the intestine:  $\times 39$ .

The infra- or sub-intestinal ganglion lying on the right side has shifted forward and has almost joined the posterior end of the pleural ganglion

of its own side. Text-fig. 25*e* is a sagittal section passing through an embryo of this stage and shows the union of the infra-intestinal ganglion with the postero-dorsal part of the right pleural ganglion, dorsally and slightly posteriorly to the statocyst.

Text-fig. 25*f* is a transverse section of an embryo in Stage 12 (Text-figs. 5*f*, 11, 25*h* and 26*a, b*) and passes through the region of the cerebral commissure and the cerebro-buccal connectives. The inner surfaces of the triangular cerebral ganglia are almost flat, while their outer surfaces are steeply arched. The optic nerve arises from the ventro-lateral area of the posterior part of the cerebral ganglion. Text-fig. 25*g* is still another section of the same series and shows that the statocysts have further sunk into the substance of the foot and now lie closely pressed against the pedal ganglia, at the level of the posterior limit of the band-shaped first pedal commissure and the second pedal commissure, which lies immediately behind and a little ventral to the extreme posterior club-shaped end of the radular sac. The infra-intestinal nerve running transversely, connects the left pleural ganglion with the right.

The supra-intestinal ganglion comes to lie on the left dorsal side, while the infra-intestinal ganglion fuses with the pleuro-pedal ganglionic mass of the right side.

Text-fig. 26*c* is an obliquely transverse section also of an embryo approximately in Stage 12. It shows the connection of the left pleural ganglion with the supra-intestinal ganglion through the left pleuro-supra-intestinal connective. The osphradio-pallial nerve is seen leaving the side of the pleuro-supra-intestinal connective and running dorso-laterally backwards to innervate the osphradium. The supra-intestinal nerve runs obliquely across the anterior lobe of the digestive gland, and connects the right pleural ganglion with the supra-intestinal ganglion.

As regards the positions of the various ganglia, they can be best understood by examining text-figs. 25*h*, and 26*a, b* which represent a series of sagittal sections of an embryo in Stage 12, passing from the left to the right side. Text-fig. 25*h* passes through the supra-intestinal ganglion lying on the left side of the embryo, below the mantle-cavity but anteriorly to the pericardium; it shows a part of the left supra-intestinal nerve which is connected anteriorly with the supra-intestinal ganglion of its own side (*i.e.*, the left), which lies to the right of the plane of this section. Text-fig. 26*a* passes through the left cerebral and pleuro-pedal ganglionic mass; it shows the cerebro-pedal and the cerebro-pleural connectives of the same side running postero-ventrally to connect the cerebral ganglion with the pedal and pleural ganglia respectively; the cerebro-pedal connective lies anteriorly and slightly internally to the cerebro-pleural connective which is thicker and stronger than the former. Text-fig. 26*b* passes through the right pleuro-pedal ganglionic mass; and shows its fusion with the infra-intestinal ganglion. The three ganglia, namely, the pedal, the pleural and the sub-intestinal, are marked off from one another through slight constrictions as shown in text-fig. 14*a*.

Text-fig. 26*d* is an obliquely transverse section of an embryo in Stage 12, passing through the entire length of the cerebro-pedal connec-

tives. A study of this series of sections shows that whereas the tentacular nerve arises from the dorso-lateral part of the cerebral ganglion, the optic nerve leaves the ganglion at its ventro-lateral part and ascends obliquely to reach the inner part of the optic vesicle of its own side and lies posteriorly to the tentacular nerve. Another nerve originating from the ventro-lateral surface of the cerebral ganglion, just ventrally to the origin of the optic nerve, runs downwards to reach the dorsal part of the statocyst of its own side (Text-fig. 26*d*). Text-fig. 26*e* passes through the cerebro-pleural connectives which lie behind the cerebro-pedal connectives (Text-fig. 15*b*) and connect the postero-ventral part of each cerebral ganglion with the inner antero-dorsal surface of the pleural ganglion.

Text-fig. 26*f* passes through the supra-intestinal ganglion. Unlike text-fig. 13*c*, in which the supra-intestinal nerve crosses over the anterior lobe of the digestive gland obliquely and joins the infra-intestino-pleuro-pedal ganglionic mass of the right side, this nerve here runs downwards and crosses over the oesophagus to pass over to the other side, since the anterior lobe of the digestive gland has disappeared by this time.

Unfortunately, I have not been able to trace the development of the intestino-visceral connectives, *i.e.*, the supra-intestinal visceral and the infra-intestinal visceral connectives of the adult. Thus I cannot say definitely whether they are formed in very early stages or later. They are so thin and slender as to make it very difficult to distinguish them from the surrounding mesenchyme cells.

*Previous work and discussion.* --All the ganglia arise independently as cell-thickenings and are of an ectodermal origin. With the exception of the unpaired visceral ganglion, they are paired structures. In *Pila*, unlike *Paludina*, *Littorina*, etc., the cerebral and the pleuro-pedal ganglia arise much earlier than the rudiments of the eye and the statocyst respectively. It is only the intestinal ganglia and the visceral ganglion which are affected by torsion. The rudiments of the intestinal ganglia arise ventrolaterally almost at the junction of the "Kopffuss" with the visceral sac rudiment, and are symmetrical, but they become asymmetrical with the progress of torsion, so that the rudiment of the right intestinal ganglion is carried dorsally and comes to lie more or less on the left side of the median plane of the head-vesicle. The rudiment of the left intestinal ganglion is carried ventrally and to the right and then shifts anteriorly, with the result that it comes to lie close to the right pleural ganglion with which it fuses to form the sub- or infra-intestino-pleuro-pedal ganglionic mass. The unpaired visceral ganglion, on the other hand, is delaminated from the epithelial thickening of the right side of the mantle rudiment and, on the completion of torsion, comes to lie against the extreme left end of the mantle-cavity, dorsally to the pericardium.

The various commissures and connectives arise secondarily after all the ganglionic rudiments have become differentiated, and are formed by the peripheral cells of the ganglionic rudiments projecting and advancing towards each other and thus giving rise to strands of cells, which later develop into "commissures" in the case of those ganglia where the strands connect the components of the same pair and



“connectives” in the case of those ganglia where the strands connect different ganglia of the same side.

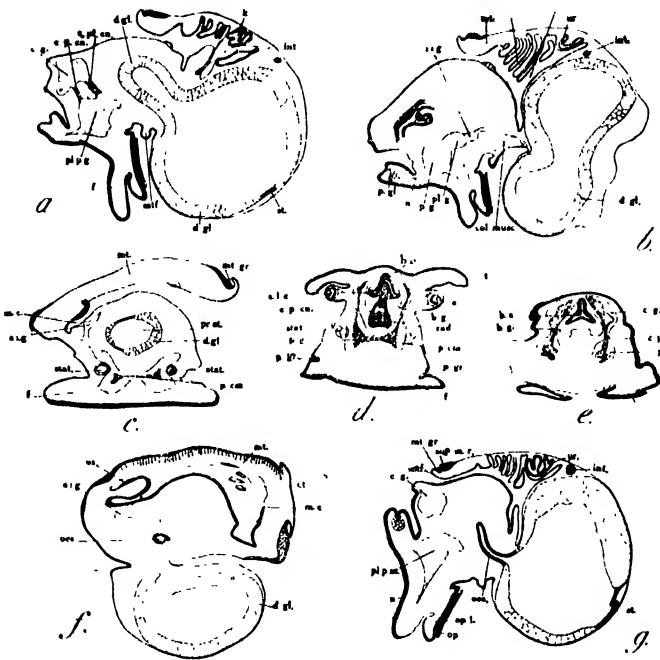
All recent work has shown that the nervous system in all the Gastropoda is of an ectodermal origin (Salensky, Haddon, MacMurrich, Schmidt, Henchman, Ihering, Erlanger, Delsman, Anderson, and others). Bobretzky (1877) in *Fusus* concluded that it was mesodermal in origin. But as MacMurrich (1886) and Rabl (1883) have rightly pointed out, Bobretzky reached wrong conclusions because of the fact that he worked on older embryos and, therefore, could not see the delamination of the nervous mass from the ectoderm. Fol (1876), though believing in the mesodermal origin of the nervous system in Heteropoda, describes the origin of the mesodermal masses (which give rise to the pedal ganglia, etc.), from the ectoderm itself.

With regard to the manner of the origin of the nervous masses, all observers are agreed that, with the only exception of the cerebral ganglia in some forms belonging to different groups of the Gastropoda, all the ganglia arise at first as ectodermal thickenings which are delaminated later to give rise to the rudiments of the various ganglia almost in the same manner as has been described by me in *Pila*. The cerebral ganglia have been observed to arise, wholly or partly, in some Gastropods like the Pteropoda, land-Pulmonates (*viz.*, *Helix*, *Arion*, *Limax*) and *Vermetus*, as ectodermal invaginations in the area corresponding to the head plates. These invaginations, one on either side<sup>1</sup>, become deeper and form tubular structures, the so-called cerebral tubes (Sarasins, 1887) which are, later, detached from the ectodermal wall and develop into cerebral ganglia (Fol, Sarasin, Henchman, Schmidt, Meisenheimer, etc.). It is stated that the cerebral-tubes alone do not form the cerebral ganglia but that they are fused at their inner blind ends with surrounding ectodermal cell-growth which is already delaminated from the head plates, to give rise to the cerebral ganglia. Whatever may be the true state of affairs, this much is certain that the cerebral-tubes do take part in the formation of the cerebral ganglia. In no other ganglion has this invagination been observed.

Again, all recent workers are almost unanimous that the various ganglia arise separately and directly from the ectoderm and become connected with one another through commissures and connectives. They have thus denied the existence of a single common median rudiment for the paired ganglia. There are, however, a few exceptions. According to Delsman (1914), the pleural ganglia in *Littorina* do not arise separately and independently but as outgrowths of the cerebral ganglia, and are not sharply marked off from the latter; they are thus the two ganglia differentiated through a constriction “(einschnürung)” of the common rudiment of the cerebro-pleural ganglion. Similarly, Heath (1916) describes that in *Crepidula adunca* “the buccal ganglia are the only ones that do not directly arise from cells migrating from the overlying ectoderm; on the other hand, they give clear evidence of being products of the cerebral ganglia”. Although Erlanger (1891) describes a separate origin of the cerebral and pleural ganglia in *Paludina*,

<sup>1</sup> In *Helix walloni*, according to P. & F. Sarasin (1887) there are two such invaginations on each side.

Anderson (1924) describes these ganglia as formed from a common rudiment.



TEXT-FIG. 26. Still more stages in the development of the nervous system.

a. Reconstruction of sagittal sections of an embryo in Stage 12, passing through the cerebro-pedal and cerebro-pleural connectives:  $\times 29$  b. Sagittal section (right of the median line) of an embryo in Stage 12, showing the complete fusion of the infra-intestinal ganglion with the right pleuro-pedal ganglionic mass and the formation of the columellar muscle:  $\times 29$ ; c. Oblique transverse section of an embryo in Stage 12, passing through the pleuro-supra-intestinal connective and the origin of the osphradio-pallial nerve:  $\times 29$ ; d. Oblique transverse section of an embryo in Stage 12, passing through the cerebro-pedal connective:  $\times 29$ ; e. Another obliquely transverse section of the same series as in (d), passing through the plane of the cerebro-pleural connective:  $\times 29$ ; f. Transverse section of an embryo in Stage 12, passing through the supra-intestinal ganglion, and the osphradium:  $\times 29$ ; g. Sagittal section of an embryo in Stage 12, showing the posterior part of the oesophagus opening into the stomach within the visceral sac:  $\times 29$ .

Lastly, with regard to the origin and formation of the commissures and connectives, all the authors, with the exception of Delsman (1914), agree that these arise from the peripheral cells of the ganglionic masses and, as they grow, extend across the spaces between the ganglia to meet similar cell-growths of either the same ganglion of the opposite side (commissure) or a different one of the same side (connective). Thus at first slender cords of irregularly arranged cells are formed which can be hardly distinguished from the surrounding cells. These commissures and connectives become distinct only when the fibrils are laid down within them. Anderson (1924) is, however, not definite as to whether the commissures and connectives arise in the manner described above, or are formed, even though partly, by direct delamination from the ectoderm, like the ganglia. He observed that in the early stages of

*Paludina*, at the time of formation of the rudiments of the cerebral commissure, the ectodermal wall lying between the rudiments of the cerebral ganglia also becomes many cells thick, but after the differentiation of the cerebral commissure, the ectodermal wall becomes single-layered again.

Delsman (1914) holds quite a different view. According to him, the ganglion, as a result of growth, becomes differentiated into a centrally situated fibrous mass, the neurofibrils, surrounded by ganglionic cells in which the nuclei are prominent and are thickly concentrated. In consequence of the strong growth, the two ganglia of each pair touch each other mesially and at the place of their meeting a bundle of nerve-fibres arising from the centrally situated fibrous mass penetrates through the surrounding layer of ganglionic cells to pass outwards to reach the other ganglion. In this way, the commissures are formed. As regards the formation of the connectives, Delsman holds a more or less different view. He says that in the embryo, though the different pairs of ganglia do not touch each other, they are also not far distant from one another. Here also a bundle of nerve-fibres arising from the neurofibrils pierces through the surrounding nuclear layer to go out and grow towards the other ganglion.

#### H. The Receptor Organs.

In *Pila* there are five localised receptor organs. Four of these, viz., the statocysts, the eyes, the tentacles and the labial palps are paired, while the fifth, viz., the osphradium (Spengel's organ) is unpaired. Unlike some other Gastropoda, such as *Paludina* (Erlanger 1891), *Littorina* (Delsman 1914), in *Pila* all these organs appear after the formation of the nerve ganglia.

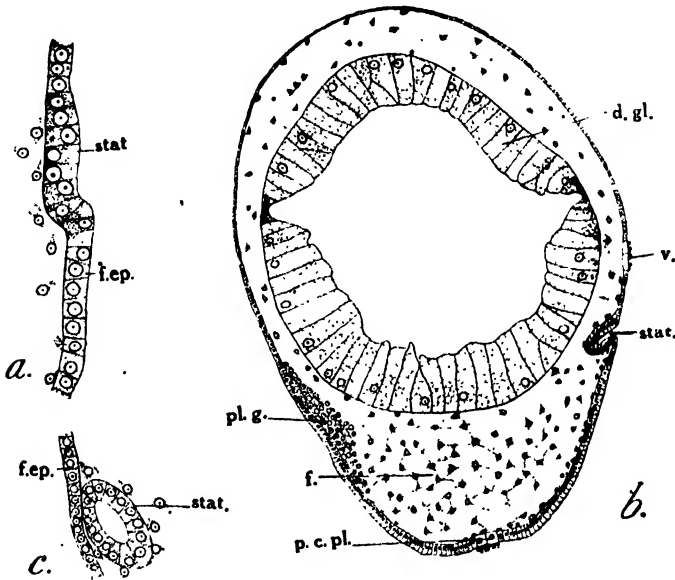
#### The Statocysts.

The rudiments of the statocysts are the earliest to appear as two ectodermal thickenings (Text-fig. 27a) which soon develop, first into flat plates and then into depressions (Text-fig. 27b) in the "Kopffuss" region at the base of the foot, a little posteriorly to the velum (Stage 8). The epithelial cells lining each depression increase in size, and multiply rapidly so that the invagination becomes deeper and tubular, although it still opens widely to the outside (Text-fig. 27b). These rudiments of the statocyst are placed obliquely and are directed inwards and downwards. The cells lining the walls of each invagination are not equal in size, those situated at its inner blind end being taller than those towards the outer opening (cf. *Paludina*, Erlanger, 1891).

As development proceeds, these invaginations become constricted off from the epithelium, and form closed vesicles lying beneath the continuous epithelium of the foot (Text-fig. 27c). The lumen of the statocyst is still narrow and tubular, and the difference in size of the cells forming its walls still persists.

With further development, the statocysts begin to shift inwards and downwards so that not only does each statocyst lie a short distance away from the epithelial wall, but a change also takes place in its shape. It now assumes an oval appearance due to a widening of its lumen, and

all its cells become more or less alike. It is still situated between the ventro-lateral wall of the digestive gland and the foot-epithelium, but is now surrounded by a few scattered mesenchyme cells.



TEXT-FIG. 27. Development of the statocyst.

a. Section of the wall of the "Kopffuss" of an embryo in Stage 8, showing the depression to form the rudiment of the statocyst:  $\times 390$ ; b. Transverse section of an embryo in Stage 8, showing the position of the statocyst rudiment:  $\times 170$ ; c. Transverse section of an embryo passing through the statocyst which is now a closed vesicle lying against the "Kopffuss" epithelium:  $\times 340$ .

With further growth, the statocysts become large while their cells become cubical and uniform in size. They shift more and more inwards, till they finally come to lie against the outer surfaces of the pleuro-pedal ganglionic masses. The outer surface of each ganglionic mass shows an indentation or depression for the statocyst (Text-fig. 28f), but in spite of this close association between the two structures the statocysts are not innervated by the pleuro-pedal ganglia. On the other hand, a nerve arising from the outer ventro-lateral margin of each cerebral ganglion runs downwards to innervate the statocyst of its own side, a part of this nerve going to the left statocysts being shown in Text-fig. 28f. This marks the final position of the statocysts. Hereafter they grow in size and statoliths are secreted within them. It has been observed that in embryos of Stage 12, a single calcareous or horny particle (statolith) or many particles (statoconia) may be present. As development proceeds, the statocysts become larger so that in a newly hatched animal these organs are large and thin-walled, the cells becoming quite flattened. In an embryo which is ready to hatch the diameter of these statocysts is about  $187\mu$ .

*Previous work and discussion.*—Semper (1862) described the formation of the statocysts in *Ampullaria (Pila) polita*, but did not make any mention of the exact process of its development. Similarly, Scott

(1934) has only described the time and stage in which these organs appear, without making any mention of their mode of origin. Semper described the otoliths (statoconia) appearing as amorphous granules which gradually become larger and crystalline. He was able to count as many as 40 such crystalline otoliths in an advanced stage. Scott counted 14 in a stage where the statocyst is  $85\mu$  in diameter.

In most Gastropoda the statocysts, as in *Pila*, originate as ectodermal invaginations, e.g., in *Patella* (Patten, 1885), *Lymnaea* (Wolfson, 1880), *Paludina* (Bütschli, 1877; Erlanger, 1891), Marine Prosobranchs (Salensky, Bobretzky, Patten, Conklin), *Bythinia* (Erlanger, 1892) and *Physa* (Wierzejski, 1905). In *Planorbis*, Rabl, considered it to be formed by invagination, though he was not quite definite at all about this. On the other hand, *Limax Maximus* (Henchman, 1890; and Meisenheimer, 1898) and *Littorina* (Delsman, 1914) show a different method of its formation. In these cases, each statocyst arises through a process of cell growth ("wucherung"), the cells being constricted off from the ectoderm as a solid mass, in which a lumen develops later.

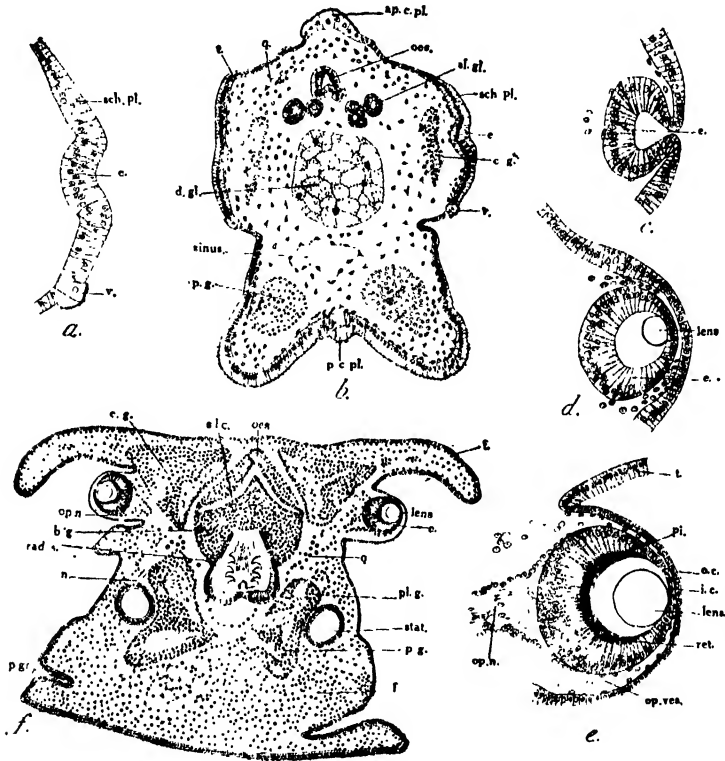
### The Eyes.

The eyes appear later than the statocysts (cf. *Littorina*, Delsman, 1914; *Paludina*, Erlanger, 1891), at a stage in which the torsion is just complete (Stage 10). The head plates become thickened about their middle and form two thick plates of tall, cylindrical cells. On each plate there appears a depression which forms the first rudiment of the eye (Text-fig. 28a, b). The eye rudiments appear simultaneously with the tentacular rudiments, the former arising on the outer and posterior sides of the latter. The cerebral ganglia, now connected with each other through a cerebral commissure, lie between the rudiments of the eyes and the digestive gland. The eye rudiments, therefore, arise in very much the same way as the statocyst rudiments.

As development proceeds, the eye depression deepens. However, unlike the statocyst, the cavity of the eye invagination is never narrow, but remains wide from the beginning up to the stage shown in Text-fig. 28c. Here, as in the case of the statocysts, a difference in the size of the cells is noticed (Text-fig. 28c), the cells forming the base of the cavity being tall and cylindrical, while those towards the outer ends and continuous with the cells of the epithelium being smaller in size. In Text-fig. 28c, the invagination shows a deep cavity which is not yet completely separated off from the epithelium of the head plate. The inner wall of the eye rudiment is nearly flat, with the result that the cavity is broader towards the inner wall, but gradually narrows down towards the outer, where it communicates with the outside through a narrow aperture. The cavity thus appears triangular in shape.

In the next stage (Text-fig. 28d), the eye rudiment has been completely constricted off from the surface epithelium, which now forms a continuous layer over the eye vesicle and consists of squarish cells. The eye vesicle is a spherical sac with a rounded cavity. The cells of the inner wall of the vesicle have multiplied and their nuclei have shifted towards the periphery, but the cells of the outer wall remain small and

have centrally situated nuclei. So far, no differentiation of parts has taken place, except for the formation of the lens which has already made its appearance in its rudimentary form. The lens is secreted by the side walls of the eye vesicle, and is a homogeneous crystalline body which later becomes spherical in outline. It lies within the lumen of the vesicle partly attached to its outer wall.



TEXT-FIG. 28. Development of the eye.

*a.* Transverse section of an embryo in Stage 10, showing the invagination of the eye rudiment:  $\times 223$ ; *b.* Transverse section of an embryo in Stage 10, showing the relative position of the eye and tentacle rudiments:  $\times 112$ ; *c.* Transverse section passing through the eye invagination which still communicates with the outside:  $\times 283$ ; *d.* Section of eye, showing the formation of the lens:  $\times 283$ ; *e.* Section passing through a fully differentiated eye of an embryo in Stage 12:  $\times 283$ ; *f.* Oblique transverse section of an embryo in Stage 12, showing the position of the eyes and showing a part of the nerve innervating in the statocyst:  $\times 81$ .

In the next stage (Stage 12), a further differentiation takes place in the vesicle (Text-figs. 28*e, f*). A black pigment is laid down at the inner ends of the tall, cylindrical cells lining the inner and side walls of the eye vesicle. The pigment, sparse in the beginning, increases in quantity as the inner layer forms the perceptive part of the eye, *viz.*, the retina. The oval nuclei become thickly crowded and lie towards the bases of the cells. The lens becomes enlarged and occupies the greater part of the lumen within the eye vesicle. It consists of a crystalline refractory substance. Fine rod-like structures develop along the inner surface of the

retina. The cells of the outer wall of the eye vesicle become flattened and their cytoplasm becomes clearer; this outer wall forms the inner cornea or pellucida of the eye. Similarly, the epithelium overlying this inner cornea forms the *outer* cornea, the cells of which become flattened in contrast to the adjacent cells which remain cubical. The nuclei of these flattened cells appear to be compressed dorso-ventrally and are hyaline in appearance, their cytoplasm also being hyaline. The epithelia of the outer and inner cornea are separated from each other by a narrow space occupied by scattered connective tissue cells. The optic nerve has already appeared at this stage and extends obliquely from the cerebral ganglion of its own side to the eye.

With further development, the eye grows in size, so that in an embryo about 3.4 mm. long, *i.e.*, when it is about to hatch, the diameter of the eye is 190 $\mu$ . It has already been described clearly that each eye is situated at the base of a tentacle at its postero-lateral margin, and is raised on a short peduncle, the ommatophore.

*Previous work and discussion.*—On comparing the development of the eye in *Pila* with that of other Gastropods, it is noticed that in *Pila* (as in *Paludina*, Erlanger, 1891; *Planorbis*, Rabl, 1879; *Limax*, Meisenheimer, 1898; *Physa*, Wierzejski, 1905), the eye arises as an ectodermal invagination which deepens and detaches itself from the ectoderm to form a rounded vesicle in which differentiation takes place later. In *Littorina* (Delsman, 1914), on the other hand, there is no invagination, but a thickening is formed which, later, gets detached from the ectoderm as a solid, rounded growth, and later develops a cavity.

The lens in *Pila*, as in *Paludina*, *Littorina*, and *Limax*, is formed as a cuticular deposit secreted by the cells of the vesicle, which increases in size by the addition of concentric layers around it (*cf.* Hilger, 1885). In *Ampullaria polita*, Semper (1862) found that the cavity of the eye-vesicle was full of a colourless fluid secreted by the wall of the vesicle before the formation of the retina. On the formation of the retina, the fluid turns yellowish, becomes thick and forms the lens. In *Lymnaea*, however, according to Wolfson (1880), the lens is formed in quite a different manner; one cell of the wall of the eye-vesicle becomes metamorphosed, its cytoplasm shrivels up and the nucleus becomes homogeneous and greatly refractory and forms the lens.

### *The Tentacles.*

The tentacles arise simultaneously with the formation of the eye. That part of each plate which lies antero-dorsally to the eye rudiment, takes part in the formation of the tentacle. At the time of its origin, this part of the head plate forms a small bulge at the extreme antero-dorsal region of the velar area (Text-fig. 28b). As soon as the tentacle-forming part of the head plate bulges outwards, the mesenchyme cells also enter the cavity of the tentacles and very soon some of the cells are transformed into muscle-fibres, which, with the growth of the tentacles, become thick in texture.

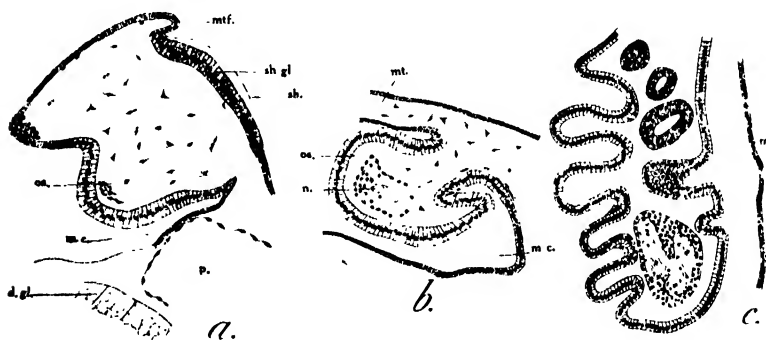
As development proceeds, these tentacles grow considerably in size, become long and tapering, and are directed antero-dorsally as well as

towards the outside. They are lined by columnar ectodermal cells (Text-fig. 28f).

As regards the development of the tentacles, complete agreement prevails amongst workers in nearly all the groups of the Gastropoda. We can thus homologise the position and development of the tentacles in *Pila* with those of *Paludina* (Erlanger, 1891), *Limax* (Meisenheimer, 1898), *Littorina* (Delsman, 1914), and others.

### *The Osphradium.*

The osphradium is an unpaired structure which arises simultaneously with the formation of the gill-rudiments just after the rudiments of the statocysts are laid down. In an embryo in Stage 8 the epithelium forming the right or inner wall of the mantle, situated just above the postero-dorsal part of the pericardium, gets thickened into a ridge-like structure from which the rudiments of the gill, osphradium and the lung arise (Text-fig. 23b). A little later, when the eye rudiments begin to appear (Stage 10), this thickened epithelium is pushed outwards into the mantle-cavity as a lamellar fold, which forms the first rudiment of the osphradium, and lies to the left of another similar formation, *viz.*, the gill-rudiment (Text-fig. 23b).



TEXT-FIG. 29. Development of the osphradium.

*a.* Section of an embryo in Stage 11, passing through the osphradial rudiment :  $\times 157$ ; *b.* Section of embryo, passing through the osphradium which now has a distinct plexus of nerves :  $\times 157$ ; *c.* Oblique section of the osphradium of an embryo about to hatch, showing its pectinate character :  $\times 157$ .

As development proceeds, the osphradium no longer remains lamellar, but changes into a more or less rounded structure (Text-fig. 29*a*).

With the growth of the mantle, the osphradium is also carried forward along with it. As it spreads out to enclose the head-vesicle, the osphradium comes to occupy its final position. It hangs down like a frill at the anterior end of the mantle-cavity on the left side of the embryo, a short distance behind the free edge of the mantle. It is now an oval structure and is broadest in the middle; its nerve has already reached its substance and is seen prominently in Text-fig. 29*b*.

As development proceeds, the ectodermal wall on either side of the osphradial rudiment is pushed inwards, thus giving rise to folds or leaflets, whilst the central part forms the median axis of the osphradium (Text-fig. 25*h*).



Text-fig. 29c is a section of the osphradium of an embryo ready to hatch. The number of folds on the two sides of the central axis has increased, giving the osphradium a bipectinate appearance.

The osphradium is an unpaired organ and retains its position on the left side throughout the course of its development. In spite of careful search, I could not observe any trace of a rudiment of the organ on the right side. According to Prashad (1925), this organ "in spite of its position on the left side is homologous to the osphradium of other Gastropods".

### *The Labial Palps.*

The labial palps or the anterior pair of tentacles arise last of all. They appear first when the embryo has already assumed an adult appearance by the forward growth of the mantle enclosing the head-vesicle (Stages 11 and 12). Like the tentacles, they arise as outpushings of the ectoderm, at the extreme antero-dorsal end of the snout, *i.e.*, the region which bounds the mouth on its dorso-lateral sides. In a newly hatched animal they appear as "short conical prolongations of the snout on the two sides of the mouth".

## X. THE LARVAL ORGANS.

In *Pila globosa*, as in other Mollusca, some organs of a transitory nature appear at one phase or another of embryonic life. These organs perform their function, if any, and then disappear completely, leaving no trace behind. Since the organs are met with only in the earlier stages of development and are not found in later embryonic stages, they have been termed as larval organs. In *Pila*, three such larval organs are present, *viz.*, (1) the velum, (2) the larval heart and (3) the "neck cells" or nuchal cells. These organs do not arise simultaneously, but originate at different periods of embryonic life.

### *The Velum.*

The velum is the first of these organs to appear at the gastrula stage, and transforms the embryo into a trochophore. Various workers who have investigated cell-lineage in the Gastropoda, such as *Crepidula* (Conklin, 1897), *Physa* (Wierzejski, 1905), *Littorina* (Delsman, 1914), have traced back the origin of the velum to the primary and secondary trochoblast cells, and this appears to be the general rule in all molluscs.

The velum consists of two band-like rows of cells which in their fully differentiated condition, are large and transparent, and bear cilia. In transverse sections, the velar cells appear wedge-shaped with the broader ciliated surface to the outside (Text-figs. 15a and 28b). To begin with, the velum is equatorial in direction, lying more towards the animal pole. Later, however, on account of the ventral protrusion of the foot-rudiment and the stomodaeal invagination, it becomes displaced on its ventral side towards the anterior end forming a curve above the mouth-opening, as a result of which two small lobe-like structures, the velar lobes, are formed on the antero-lateral sides, which are characteristic of a veliger.

The velum is a ciliated organ which helps the embryo to rotate within the egg-shell, although I have never seen these rotatory movements myself. The velum persists up to a pretty late stage (Stage 11), but when the embryo is fully developed, it becomes absorbed within the body-wall epithelium and disappears. The disappearance begins on the dorso-lateral sides and is completed before the embryo hatches out.

### *The Larval Heart.*

The second larval organ is the so called larval or embryonic heart. In the posterior region of an embryo in Stage 6 (Text-fig. 4f), between the posterior part of the foot and the anus, irregular contractile movements are seen in the body-wall on the right side. These movements occur long before the definitive heart starts pulsating. It is the thin body-wall in this region which exhibits the pulsations in the form of strong movements of expansion and contraction. The position and functioning of the larval heart can be best studied in the living condition, since after fixation this region generally evinces a systolic phase, and it is very rarely that a distended condition is met with. The larval heart consists of a bulge of the ectoderm to which a large number of mesenchyme cells are closely attached on the lower side.

Although the first pulsations of this organ are seen in Stage 6, I am inclined to believe that it functions even earlier, and the pulsations have been overlooked on account of the opacity of the embryo and the feebleness of the movements. Only when this "heart" has developed appreciably and the embryo becomes more or less transparent with the complete absorption of the food-yolk, that the pulsations are readily observed.

These pulsations have been connected with embryonic circulation by some authors, *e.g.*, Fol. (1880), who suggest that circulation of the body-fluid is promoted through its contractions. The larval heart continues to pulsate even when the true or definitive heart has begun its rhythmic beats. I could observe the contractile movements of the larval heart at a stage when it is enclosed by the forwardly growing mantle (Stage 11, Text-fig. 5d). At this stage the shell covering the visceral sac is still thin and sufficiently transparent to allow the movements within to be readily seen. The duration of the larval heart could not be definitely ascertained, as the shell, becoming opaque, shuts it out of view, but it is certain that it disappears long before the hatching of the embryo.

Semper (1862) describes in *Ampullaria polita* such a larval organ as a chamber at a place exactly comparable to that in *Pila*. He, however, describes the presence of a short muscle extending from the skin to the liver mass and dividing this chamber into two (*cf.* his fig. 14 S, Pl. 11). An examination of living embryos and whole mounts, as well as transverse and sagittal sections, failed to show any trace of such a muscle. Scott's observations on *Ampullaria canaliculata* (1934) support my conclusions about the absence of this muscle.

Salensky (1872) has likewise demonstrated the presence of a larval heart in *Calyptraea*, while Robretzky (1877) observed it in *Nassa* and *Fusus*. Fol. (1880) describes the appearance of this larval organ

amongst the *Pulmonata*, such as *Helix*, and similarly, *Delsman* (1914) noticed its appearance in *Littorina* and *Fusus*.

### *The Nuchal Cells.*

The third larval organ is a group of specialised cells which first appear within the velar area in the region of the head plates. They are definitely noticed for the first time, when the torsion of the embryo has just been completed (Stage 10). These cells are mostly rounded in shape and have centrally situated nuclei containing distinct nucleoli (Text-fig. 30a). They differ from the rest of the mesenchyme cells found scattered within the body-cavity not only in their much larger size but also in their capacity to take a deeper stain. After observing their constant presence within the neck region amongst the *Pulmonata*, Fol' (1880) designated them as the "neck-cells" ("cellules nuchales"). Since nothing definite has been established as regards their morphological or physiological nature, this designation has been accepted by subsequent authors like Erlanger (1891) and Wierzejski (1905).



TEXT-FIG. 30. Nuchal cells.

a. Nuchal cells of an embryo in Stage 11. b. Nuchal cells of an embryo older than Stage 12, showing the formation of vacuoles. Both figures semi-diagrammatic.

At the time of their appearance, the nuchal cells are few in number and are situated in the dorsal part of the head-vesicle near the part of the head plates lying in the neighbourhood of the posterior part of the cerebral ganglia. They are already arranged in a semi-circle, corresponding to the next stage of development in *Paludina* and *Physa*. But I believe that in *Pila* too they probably originate as two lateral plate-like cell-groups in a stage immediately preceding the one under discussion, but are not sufficiently differentiated to be readily recognisable. These cell-groups extend towards each other, meet dorsally above the oesophagus, and finally produce a semi-circular or horse-shoe-shaped appearance.

As development proceeds, these cells multiply, and spread inwards and downwards on either side of the radular sac, so that they lie scattered in the space between the body-wall and the fore-gut, right up to the lower end of the radular sac. The nuchal cells not only increase in number but also show a marked growth in their size and become more prominent.

Later, vacuoles appear within these cells, as a result of which they become distended, while their shapes get distorted and irregular (Text-fig. 30b). The vacuoles are small to begin with, but soon grow large and displace the nuclei from their original central position towards the periphery.

A close study of these cells in various stages of development shows that they continue to lead an independent existence

without participating in the formation of any organ whatsoever, that they persist for some time after the formation of vacuoles and changes in their shape, and that they disappear completely when the embryo is ready to hatch. No trace of their existence has been observed either in embryos ready to hatch or in the newly hatched animals.

*Previous work and discussion.*—Nuchal cells have been described in some other fresh-water Gastropods, viz., *Paludina*, *Bythinia* (Prosobranchs), and *Lymnaea*, *Planorbis*, *Ancylus* and *Physa* (Pulmonates); but they have not been observed in the terrestrial Pulmonates. Wierzejski (1905), on account of their position, considers them to be analogous with the external kidney of the marine Prosobranchs.

As regards their morphological and physiological significance nothing definite is known. Fol. studied them in *Ancylus*, *Planorbis* and *Lymnaea* and describes them as special mesodermal cells which have delaminated from the ectoderm. According to Erlanger (1891), the nuchal cells arise as an unpaired plate-like extension ("verbreitung") in the mid-dorsal line of the posterior border of the velum, and are thus ectodermal in origin. Wierzejski (1905), on the other hand, describes them in *Physa* as mesodermal in origin, having been derived from the secondary mesoderm as a paired rudiment close to the dorsal edges of the head plates which later extend towards each other in the middle line above the pharynx and thus form one semi-circular cell-plate. According to him, there is no genetic relation either with the velum as considered by Erlanger, or with the head plates. In *Pila*, so far as I have been able to ascertain, the origin and development of these cells accords with the findings of Wierzejski.

Similarly, contradictory views are held as regards their physiological significance. Lereboullet (1862) regarded them as nervous elements, while Lankester (1874) mistook them to be rudiments of cerebral ganglia. Fol. (1880) believes them to be remnants of a rudimentary organ. Erlanger (1891), though silent about their actual significance in *Paludina*, mentions a casual connection between the appearance of these cells and the absorption of the velum. Wierzejski (1905) suggests that on account of (1) the presence of these cells close to the primary kidneys, (2) the early appearance of these cells, and (3) their becoming large and vacuolated at the time of the atrophy of the primary kidneys, these cells seem to be concerned with an excretory function. But this view cannot hold good in *Pila*, since the nuchal cells (i) appear in later stages, i.e., in Stage 10; (ii) are not at all related to the primary kidneys, as the latter are absent in *Pila*; and (iii) because in *Pila* these cells attain their maximum size and get vacuolated in stages when the real kidney is already functioning (Stage 12). I, therefore, hold that the nuchal cells constitute an independent larval organ of problematic function.

## XI. THE FOOT.

### *General Development of the Foot.*

The origin of the foot and the structural changes it undergoes have already been described above. The foot is composed exclusively of ectodermal and mesenchymatous cells. As development proceeds, the base of

the cone at its junction with the head-vesicle anteriorly and the entire anterior surface of the cone both increase in size. The posterior surface of the cone does not grow at the same rate. The result of this differential growth is, that the area at the anterior junction of the foot and head-vesicle forms the anterior ascending surface of the foot, the anterior surface of the cone comes to form the flat sole of the foot, while the slow-growing posterior surface forms the postero-dorsal wall of the foot. The pedal cell-plate persists up to Stage 12 but disappears later. When the foot has flattened (Stage 10), cilia develop on its entire ventral surface (Text-fig. 28 *b*.) These cilia are extremely fine in the earlier stages of their development and are evenly distributed over the sole of the foot (*cf.* Barr, 1928 ; Roth, 1929).

In later stages of development when the embryo has assumed a snail-like appearance (Stages 11 and 12 : Text-figs. 5*d*, *e*, *f*), a notch-like invagination appears close to the extreme posterior end of the foot, at the junction of the sole and the posterior surface (Text-fig. 10). This invagination gradually deepens and extends upwards on either side of the foot so as to reach as far as the junction of the foot with the posterior end of the head-vesicle, close to the place where the latter meets the visceral sac. As a result of this extension of the invagination, the postero-dorsal part of the foot becomes raised and is distinguished as a disc-like structure more or less constricted from its ventral part. This may be called the operculigenous disc or lobe of the foot, *i.e.*, that part of the foot which secretes and bears the operculum (Text-figs. 10 ; 11 ; 25*h* ; and 26*a*, *b*, *g*).

Similarly, at about this stage (*i.e.*, Stage 12), an ectodermal invagination, takes place in the anterior wall of the foot. This is notch-like to begin with, but soon deepens posteriorly into a small and narrow groove-like structure. This is the rudiment of the pedal gland (Text-fig. 11).

### *The Epithelium of the Foot.*

In the earliest stages, the cells lining the walls of the foot are all alike in being tall and cylindrical (Text-fig. 15*a*). They are closely pressed against one another, are rich in protoplasm, and are provided with centrally situated oval or ovoid nuclei. Gradually, however, the cells towards the base of the conical foot become smaller than those towards the apex of the cone (Text-fig. 27*b*). This change in size and shape proceeds dorso-ventrally, both along the anterior wall of the foot as well as along its lateral walls, till, finally, in a completely flattened foot only the cells of the sole of the foot remain tall, cylindrical and glandular with oval or rounded nuclei (Text-fig. 28*f*). The cells bounding the postero-dorsal area of the foot, *i.e.*, those forming the operculigenous disc, remain unaffected by these changes and they retain their columnar and glandular character. The horny, membranous rudiment of the operculum is secreted by these cells in the same way as the shell is secreted by the shell-gland, with this difference that there is no invagination in the area of the operculigenous disc, and the surface remains flat. The rudimentary operculum later becomes calcareous<sup>1</sup>.

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<sup>1</sup> I have, however, not followed the development of the operculum.

The cells lining the sole of the foot undergo a change. Their nuclei move towards their bases, *i.e.*, towards the end opposite the one that bears the cilia. These cilia are not confined to the sole of the foot but also extend upwards along the edges of the foot so as to reach dorsally the lower margin of the lateral grooves, which are formed at this stage as ectodermal invaginations, one on either side, occurring in the antero-lateral part of the foot close to the foot-fringe<sup>1</sup>. These lateral grooves correspond to the peripodial grooves of *Arion* as described by Barr (1928), with this difference that in *Pila* they do not extend as far back as the posterior end of the foot, but are confined to its anterior part. They are deeper anteriorly but gradually become shallow till they disappear altogether. I noticed the presence of these grooves for the first time in Stage 11.

Another structure within the foot, is the columellar muscle. In very early stages, when the foot has just flattened at its anterior end (Stage 6), the mesenchyme cells become thickly concentrated in the posterior part of the foot. With further development, the number of these cells increases and they aggregate towards the left posterior side. When the embryo has assumed a snail-like appearance (Stage 11, Text-fig. 10), the cells of the aggregated mass begin to differentiate into elongated spindle-shaped cells with centrally situated nuclei; these are the muscle cells. This differentiation extends from the posterior to the anterior end, till nearly all the cells of the mass become transformed into the muscle cells. These cells form the rudiment of the columellar muscle. A fully differentiated columellar muscle extends over the entire surface of the operculigenous disc of the foot beneath the operculum. In an extended foot, the muscle appears as an arched structure directed anteriorly with the convexity of the arch lying at the junction of the foot with the head-vesicle (Text-fig. 11). The muscle is broad at its anterior end, but posteriorly it is narrow and band-like and lies to the left of the oesophagus. It helps in the retraction of the foot within the shell.

In addition to this muscle, other muscle fibres and strands, which lie interspersed within the foot and cross one another, develop by the transformation of the mesenchyme cells and thus form the musculature of the foot.

#### *The Pedal Gland.*

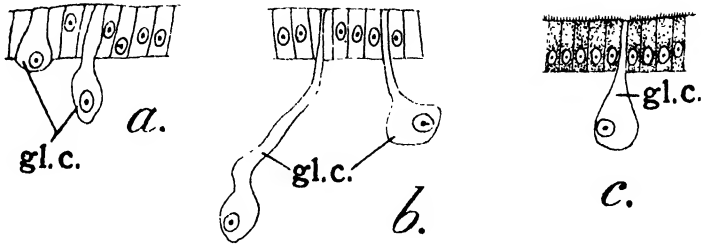
The origin of the pedal gland as an ectodermal invagination at the anterior end of the foot has been already pointed out. With further development the invagination deepens and extends backwards in a horizontal direction within the substance of the foot, almost parallel to its ventral creeping surface. It is tubular in appearance and is confined to the anterior part of the foot (Text-fig. 11).

At first this tubular rudiment is lined throughout with small cubical cells but soon some of the cells at the inner blind end of the tubular invagination increase in size and sink into the subjacent connective tissue mass. Here they swell up into irregular oval bulb-like shapes

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<sup>1</sup> The lateral margins of the sole are designated as the foot-fringe.

with their nuclei in their swollen bases. These swollen cells vary in size and together form a compact mass around the posterior end of the invaginated tube, and constitute the glandular mucous cells of the pedal gland, while the undifferentiated tubular part functions as the canal for the slime secreted by the glandular cells. These secretory cells do not take up stains easily.



TEXT-FIG. 31. Three successive stages in the development of the gland cells of the foot in the developing embryo. In (c) a gland cell is seen opening on the sole of the foot:  $\times 447$ .

As development proceeds, the secretory cells increase in size and sink further into the subjacent mass of connective tissue, but retain their connection with the tubular canal through their narrower proximal parts. The slime secreted by the mucous cells is thus discharged directly into the secretory canal.

#### *Other Glands of the Foot.*

Besides the pedal gland, there are a few others found within the foot. I have arranged them, on the basis of their position, into three different groups.

(1) The first group includes glands that are situated in the neighbourhood of the lateral grooves into which they open. These correspond to the "peripodial glands" of *Arion* (Barr, 1928), and resemble them in form and structure and are ectodermal in origin. They arise almost simultaneously with the pedal glands and are always unicellular. They are mucous glands which discharge their slimy secretion into the lateral grooves. From the lateral grooves the secretion is carried anteriorly to the opening of the pedal gland by the cilia lining the outer borders of the grooves<sup>1</sup>.

(2) The second type of glands are confined to the antero-dorsal part of the foot. The covering epithelium of this part of the foot consists

<sup>1</sup> Barr (1928) states that in *Arion* "the cells discharge their mucus into the intercellular spaces, especially into those that are situated just below the canal. From there the mucus passes out into the lumen of the canal. This process is probably assisted by the contraction of the muscles which are found between the cells. Some of the glandular cells (i.e., those in the roof of the canal and round its dorsal half) discharge their contents directly into the canal". I do not see any justification for this view as the whole of the secretion is directly discharged into the lumen of the canal itself. The mucous cells are of epithelial origin and sink into the substance of the connective tissue but they never lose their connection with the epithelium. In sections, one can not always see their connections with the epithelium without reconstruction, and hence can easily be misled to think that they discharge their contents into the intercellular spaces. Barr himself has noticed the mucous cells in the roof opening directly into the canal.

of tall cylindrical cells with oval or elliptical nuclei in the basal ends of these cells.

In an embryo in Stage 11, some of the epithelial cells lining this surface sink inwards (Text-fig. 31a) and take up a deeper stain than that of the adjacent epithelial cells. The nuclei in these cells become large and round and pass into their epithelial portions.

As growth proceeds these glandular cells sink deeper till they come to be imbedded in the deeper parts of the sub-epithelial mass of the foot (Text-fig. 31b). The proximal parts of these cells become very much narrowed into long tubular neck-like structures which serve as the ductules for the secretion to be discharged on the surface of the foot. On their further migration inwards, these ductules elongate and become tortuous in their course, with the result that one must examine a number of sections to trace the entire course of these cells and their ductules, which are continuous right up to the outer epithelium (Text-fig. 31b). Since these cells are continuously being differentiated from the ordinary columnar cells, they are seen at different stages of development and are of different sizes in the same embryo. They vary in shape from the vesicular to rhomboidal.

(3) The third set of glands are confined to the sole of the foot and are, therefore, aptly described as the foot-sole glands. These are also unicellular like the others, and appear much later, when the embryo is ready to hatch. They arise and develop from the epithelium of the sole of the foot and resemble more or less the gland-cells belonging to the second group (Text-fig. 31c).

#### *Some other structures connected with the Foot.*

The lateral grooves, on either side, mark the boundary between the epithelium of the foot-fringe and that of the lateral walls, the cells lining the foot-fringe and the sole being tall and ciliated, while those lining the lateral walls are small and non-ciliated.

The other structures found within the foot are : (1) two statocysts, (2) the two pleuro-pedal ganglia with their commissures and connectives, and (3) the lower distal part of the unpaired radular sac with its associated musculature (Text-fig. 28 f). Of these, the first two are directly related to the foot because of their origin by invagination and delamination, from the ectodermal epithelium of the foot. These two structures have been separately described in the chapter on the nervous system and the receptor organs.

The radular sac, however, arises from the fore-gut and developmentally is entirely unconnected with the foot. It is only due to its increase in length that in later stages it penetrates into the foot, lying between the two pleuro-pedal ganglionic masses. The musculature of the radular sac and the so-called supporting cartilages of the odontophore is partly derived from the mesenchymatous cells of the foot.

## XII. THE SHELL-GLAND AND THE MANTLE.

The origin and development of the shell-gland as a thickened plate of tall glandular cells on the postero-dorsal surface of the embryo (Text-figs. 4 a, b ; and 6 a) and the further changes it undergoes, firstly through



invagination, and secondly, through eversion and change in position, have already been fully described already.

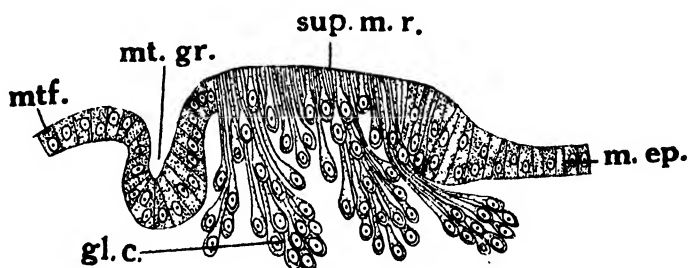
After the invagination of the shell-gland is complete there is an eversion of the gland. The cells lining the central, everted area become smaller in size and are more or less flattened, while the peripheral area, which is bounded on the outside by the mantle fold and the mantle groove, still consists of tall and columnar cells (Text-figs. 9 and 23a). This peripheral area represents the rudiment of the shell-gland of the adult.

At the time the shell gland invaginates, its margin forms a raised fold all round the gland, the fold projecting inwards towards the centre of the invagination. This is the mantle fold which, in earlier stages, is more marked anteriorly than posteriorly (Text-fig. 4 f), with the result that the mantle groove, running all round beneath the mantle fold, is also deeper anteriorly than posteriorly. In later stages, the mantle fold forms the anterior free end of the mantle (Text-figs. 10 and 11).

The rudiment of the shell is secreted first as a thin cuticular membrane from the shell gland when the latter still forms an invagination on the left side of the visceral-sac rudiment (Stage 6, Text-fig. 4 f). It forms a thin cap-like structure covering the shell-gland. It is against the inner surface of this cuticular shell that the calcareous parts of the shell (ostracum and hypostracum) are later deposited.

The rudiment of the mantle is differentiated from that part of the visceral-sac rudiment which is bounded by the mantle fold and the mantle groove at its free end, and is lined on its left side by tall columnar cells of the shell gland (Text-fig. 23a).

On the completion of torsion, the mantle comes to lie dorso-laterally, and with-further growth moves forward to enclose the head-vesicle dorso-laterally (Text-fig. 5 d). During this period, the mantle fold becomes thick and the mantle groove well-defined. The central everted area of the shell-gland, which now consists of completely flattened cells, forms the outer epithelium of the visceral sac.



TEXT-FIG. 32. Sagittal section passing through the adult shell gland and the mantle groove, and shewing the glandular cells of the supra-marginal ridge:  $\times 447$ .

The mantle epithelium, at the free edge of the mantle, *viz.*, the mantle fold, is lined by a single layer of cubical cells of uniform height, with a rounded nucleus in the middle of each cell. These cells continue posteriorly and line the inner epithelium of the mantle. On the outer side of the mantle, however, the mantle groove (=supra-marginal groove of Prashad, 1932), which is still sufficiently deep in Stage 11, is lined with a single row of columnar cells of varying height, the cells lining

the anterior wall of the groove being shorter in height than those which line its posterior wall. Immediately posterior to the mantle groove lies, as in earlier stages, the rudiment of the shell-gland of the adult. The latter still consists of a single layer of tall columnar and glandular cells with a centrally situated nucleus in each cell. These cells gradually diminish posteriorly in their height and merge imperceptibly into the small and flattened cells of the mantle (Text-fig. 10).

In later stages of development (Stage 12), the region of the shell-gland becomes more marked and its surface becomes raised a little above that of the rest of the mantle (Text-fig. 11). This raised area forms the rudiment of the supra-marginal ridge (Prashad, 1928). The cells constituting the supra-marginal ridge have become further differentiated. They are now taller than in the preceding stages and have sunk deep down into the subjacent connective tissue. The nuclei of these cells moving from their original central position, come to lie at the inner or ventral ends of the cells. The supra-marginal ridge is now restricted to a limited and defined area (Text-fig. 11).

With further development, the tall glandular cells of the supra-marginal ridge become swollen or rounded at their inner ends and thus appear more or less flask-shaped (Text-fig. 32). The ovoidal nuclei lie in the rounded ends of these cells, which are now arranged more or less in bundles, the individual cells being curved in their lower halves (*cf. Paludina*, Prashad, 1928). This curvature is due to lack of space, the cells being pushed sideways into the connective tissue, a view also held by Prashad.

In an embryo about to hatch, some calcareous structures are found lying imbedded in the connective tissue at the base of these flask-shaped cells. They are small refractive bodies which, according to Prashad, gradually pass into the glandular cells of the supra-marginal ridge which secretes the ostracal layers of the shell. At this time pigment is found in the outer epithelial covering of the mantle, which extends posteriorly behind the supra-marginal ridge. The pigment granules<sup>1</sup> are confined to the upper parts of the cells. It is the outer general covering of the mantle which is responsible for the secretion of the innermost or hypostacal layer of the shell.

The mantle groove, during the course of its development, does not remain unchanged. Its lumen becomes reduced on account of the encroachment of the differentiated cells of the supra-marginal ridge (Text-fig. 32).

*Previous work and discussion.* Semper (1862) did not notice in *Ampullaria polita* the first formation of the shell-gland on the aboral surface of the embryo. The stage which he described as the "erste Anlage der Schale" is a later stage, where the shell gland has already shifted to the left side (Stage 5) and the shell secreting area is lying as an oval disc consisting of small polygonal cells. Fernando (1931) describes it as a depression on the postero-dorsal surface of a trochophore, but he does not describe its structure, though his figs. 1 and 4,

<sup>1</sup> I have not traced the origin of the pigment granules, but according to Distaso (in *Helix* and other Gastropoda, 1908) and Prashad (in the Viviparidae, 1928), and others, they are derived from the nuclear chromatin of the chromatophores.

Pl. I show it as being composed of polygonal cells, a condition which is also noticed in *Pila globosa* when the sections are oblique.

Scott (1934), while making no mention of the structure of the shell-gland, in *Ampullaria canaliculata*, describes it as a depression on the postero-dorsal surface of the embryo. This depression follows the same course in later development as I have described in *Pila globosa*.

In the case of those Molluscs whose cell-lineage has been completely traced, e.g. *Crepidula* (Conklin, 1897), *Planorbis* (Holmes, 1900), *Physa* (Wierzejski, 1905) *Littorina* (Delsman, 1914) and others, it has been definitely established that the shell-gland is formed by the descendants of the first somatoblast, 2nd or X, showing thereby that in all Molluscs it is derived from the same region of the developing egg. This region forms the aboral surface and extends from behind the velum to the posterior end of the embryo.

### XIII. THE MANTLE-CAVITY.

The rudiment of the mantle-cavity, first formed in the mid-ventral region of the visceral-sac rudiment, arises as an ectodermal invagination almost in the same transverse plane as the right and left rudiments of the pericardium (Text-fig. 16c). The invagination sinks deeper and forms a groove-like structure from the inner end of which the rudiments of the right and left ureters take their origin, these latter being hardly distinguishable in their earlier stages from the rudiment of the mantle cavity.

All the stages of development of the mantle cavity, from its mid-ventral position (Stage 2) to its final definitive dorsal position (Stage 10), have already been described above (pp. 233 and 246). It was stated that by the time the mantle-cavity reaches its definitive dorsal position, it no longer remains tubular but becomes a wide and spacious cavity enclosed dorso-laterally by the mantle (Stages 10 and 11). The anus opens for the first time into the mantle-cavity just when the latter, on account of complete torsion, comes to lie on the dorsal side of the embryo, and the rudiments of the gill and the osphradium are projecting into it from the inner surface of the mantle (Stage 10).

As the embryo assumes a snail-like appearance (cf. Stage 11), an antero-posterior fold, the *epitaenia* running in an obliquely longitudinal direction, arises from the base of the mantle cavity and grows vertically upwards. It forms a septum incompletely dividing the mantle cavity into two chambers of unequal size. The larger right chamber contains the gill and the anal, excretory and genital apertures and is called the branchial chamber. The smaller left chamber is, on account of the presence in it of the osphradium and the lung, known as the pulmonary chamber.

Thus, we find that the mantle cavity in *Pila globosa* is an ectodermal structure, mid-ventral in position at the time of its origin. But as a result of dextral torsion, it is rotated through 180° to occupy its final definitive dorsal position.

*Previous work and discussion.*—According to Fernando (1931), the rudiment of the mantle cavity in *Pila gigas* arises as an ectodermal invagination which later acquires a lumen. He does not, however

specify the exact position of this rudiment. His description of the later stages of its development agrees with mine.

As regards the origin of the mantle-cavity in other Gastropoda, Erlanger (1891) describes it as an unpaired small depression on the ventral surface of the posterior part of the embryo, while Drummond (1903) and Otto and Tönniges (1905) describe a paired rudiment of the mantle-cavity, one on either side of and below the intestine, the right one being larger than the left. Drummond says that "it is only at a later stage that a portion of the body immediately in front of the anus sinks in and unites the two original depressions, thereby including the anus in the mantle-cavity". The two depressions are, according to Drummond, never symmetrical.

Delsman (1914), who studied it in *Littorina* only in the earlier stages of development, describes the rudiment of the mantle-cavity as situated in the beginning on the right side.

Amongst marine Prosobranchs, viz., *Nassa mutabilis* and *Fusus* (Bobretzky, 1877), the rudiment of the mantle-cavity, being asymmetrical, arises as a sickle-shaped ectodermal invagination on the right side of the embryo.

Amongst the Pulmonates also, the rudiment of the mantle-cavity arises either as a simple shallow depression or slit-like invagination which on deepening leads to the formation of the mantle-cavity. It arises independently of the lung, though the two are intimately connected. In *Planorbis*, according to Rabl (1875), the rudiment of the mantle-cavity originates in a different manner: it originates by the raising of the mantle-folds from the body-surface to which they are closely attached in the earlier stages, and thus a slit-like space is produced which later develops into the mantle-cavity. But in *Helix* (1880) he describes the rudiment of the mantle-cavity to be formed as an ectodermal invagination. In *Limax*, according to Meisenheimer (1898) the mantle-cavity arises by the "secondary" rolling up of the shell-folds (=mantle-folds) but Heyder (1909) considers that "the formation of the mantle-cavity is a continuous and progressive growth so that a primary formation and a secondary rolling up (as pointed out by Meisenheimer) can hardly be admitted". On this basis, Heyder regards the primary arching of the mantle-fold as the first rudiment of the mantle-cavity. Heyder (1909) describes the rudiment of the mantle-cavity in *Arion* as a groove on the right side of the embryo which, therefore, is asymmetrical.

#### XIV. SUMMARY.

1. Oviposition takes place on land. Each egg is composed of a thick calcareous shell, two thin membranes (the shell-membrane and the albumen-membrane), a solid albuminous sphere, and the albuminous fluid in which the embryo floats.

2. Cleavage is total and of the spiral type, the first two divisions being equal, inequality stepping in at the third division. Only three quartettes of micromeres are segregated to give rise to the ectoderm. The macromeres give rise to the endoderm and the mesoderm.

3. The cleavage-cavity appears very early at the 2-cell stage.

4. The blastula has a large blastocoele.
5. Gastrulation is embolic.
6. The mesoderm is teloblastic in origin.
7. The blastopore persists and is transformed into the anus.
8. All the essential organs are developed during the embryonic stage, and the embryo hatches out when it fully resembles the adult in all important respects.

9. The first rudiment of the alimentary canal is the endodermal archenteron from the anterior blind end of which the stomach and the digestive gland arise, while its posterior part gives rise to the intestine. In early stages, folds arise internally from the wall of the primitive stomach for the assimilation of the ingested albumen: as development proceeds these folds are absorbed.

10. The stomodaeum or fore-gut is ectodermal and is formed by invagination. Later, the stomodaeum becomes differentiated into an anterior part including (i) the buccal-cavity, and (ii) a posterior part including the oesophagus. The radular sac, the sub-lingual cavities, the oesophageal pouches and the salivary glands all arise from the anterior part.

11. The radular sac arises as a mid-ventral outpushing from the floor of the stomodaeum, the basal membrane being secreted by the basal epithelium of the sac. The radular teeth are secreted by the odontoblasts which are many in number and are differentiated at the blind distal end of the radular sac. There are only seven teeth in each cross row. The lateral pair of teeth are the first to be differentiated. These are followed by the marginal pairs, while the median tooth is the last to be differentiated. The dorsal epithelium of the sac forms cell-complexes projecting in between the apices of the teeth.

12. The salivary glands evaginate from the postero-dorso-lateral walls of the buccal-cavity as simple tubular structures which become branched subsequently.

13. The digestive-gland evaginates from two rudiments. Of these, the anterior one is differentiated from the cells lining the walls of the primitive stomach lying within the head-vesicle, while the posterior is formed later from the posterior end of the primitive stomach and lies within the visceral-sac rudiment and develops into the digestive-gland of the adult. The anterior rudiment is absorbed in the later stages of development.

14. The stomach is differentiated from the right ventro-lateral side of the posterior end of the primitive stomach.

15. A common rudiment for the kidney, the pericardium, the heart, and the gonad is differentiated in the form of two ventrally situated mesodermal cell-masses, one on either side of the intestine in the visceral-sac rudiment. A lumen appears in each cell mass (representing the coelom) giving rise to the rudiments of the pericardium, etc. The two rudiments, meeting together, fuse to form a single structure divided by a septum which subsequently disappears.

16. The rudiments of the right and left kidneys arise in the form of two thickenings of the postero-ventral walls of the right and left pericardial cavities. The right one evaginates and forms a sac-like

structure which subsequently becomes lamellar and develops into the definitive (left) functional kidney of the adult.

17. The left kidney rudiment persists as a rudimentary structure and takes part in the formation of the genital duct.

18. The ureter (=anterior kidney) evaginates from the inner end of the mantle-cavity as a tubular structure and is thus ectodermal in origin. It develops, later, into the lamellar organ of the adult.

19. The efferent duct of the left rudimentary kidney also evaginates from the inner left end of the mantle-cavity and remains rudimentary, to be transformed later into the genital duct.

20. The heart arises as an unpaired thickening of the pericardial wall which invaginates later and forms a tubular organ. This becomes constricted in the middle to give rise to the auricle and the ventricle.

21. The blood-vessels arise independently of the heart and originate in sinuses in the body-cavity, enclosed by mesenchyme cells.

22. The gonad is differentiated from the roof of the pericardium as an unpaired thickening. It lies very close and dorsally to the left kidney rudiment with which it fuses to communicate with the mantle-cavity through the rudimentary efferent duct of the left kidney.

23. The gill arises as an unpaired rudiment in the form of a series of outpushings from the right or future inner wall of the mantle rudiment just dorsally to the right of the pericardium.

24. The lung originates as an invagination of the mantle epithelium between the rudiments of the gill and the osphradium. It is neither an invaginated gill-filament nor is it homologous with the lung of the Pulmonates.

25. The nervous system is ectodermal in origin. All the ganglia arise separately as ectodermal thickenings which are delaminated and only become connected later through commissures and connectives.

(a) The cerebral ganglia arise from "head plates" (=the "Scheitel plattes") of the German authors, and "Sinnesplatte" of Schmidt.

(b) The pedal and pleural ganglia arise as separate rudiments from the lateral walls of the "Kopffuss," more or less ventrally to the place for the origin of the statocysts.

(c) The buccal ganglia arise from the stomodaeum close to the region of evagination of the radular sac.

(d) The intestinal ganglia are symmetrical in the beginning and arise ventro-laterally at the place where the "Kopffuss" and the visceral-sac rudiment meet.

(e) The visceral ganglion is unpaired and delaminates from the right wall of the visceral-sac rudiment, and is situated dorsally to the level of the pericardium. It originates much earlier than the differentiation of the mantle rudiment.

26. The statocysts arise at first as flat, plate-like thickenings which invaginate deeply and get detached from the overlying epithelium of the foot. They originate much later than the pedal and pleural ganglia.

27. The eyes arise as invaginations in the region of the head plates, which become detached from the over-lying epithelium to form the optic vesicles. The lens in each is secreted by the walls of the vesicle.

28. The tentacles originate as outpushings of the "Scheitel plattes".

29. The osphradium arises as an outpushing of the inner wall of the mantle rudiment, close to and almost in the same plane as the rudiments of the gill and the lung.

30. The mantle-cavity arises as a single tubular ectodermal invagination of the visceral-sac rudiment, immediately below the mesodermal cell-masses. The anus, which at first lies posterior to it, opens into it when torsion is complete.

31. The foot arises as a mid-ventral protrusion from the post-velar area. The pedal gland is formed by an invagination of the outer epithelium at the anterior end of the foot. The other glands found within the foot are also of epithelial origin. The operculigenous lobe is demarcated at the postero-dorsal surface of the foot, the operculum being secreted from its dorsal surface.

32. The shell gland arises as an ectodermal thickening at the aboral pole. It first invaginates and later gets everted. During eversion, while the cells of the central region of the everted shell gland become thin and flattened to form the outer epithelium of the visceral sac, its marginal cells remain tall and columnar and give rise subsequently to the shell-gland (=supra-marginal ridge) of the adult.

## XV. EXPLANATION OF LETTERING IN TEXT-FIGURES.

*a.*, Anus. *an. c. pl.*, Anal cell-plate. *ant.*, Anterior end. *a.p.*, Animal pole. *ao.*, Aorta. *ap. c. pl.*, Apical cell-plate. *arch.*, Archenteron (or primitive stomach). *arch. c.*, archenteric cavity. *arch. f.*, Archenteric folds. *au.*, Auricle. *au. vent. ap.*, Auriculo-ventricular aperture. *bas. m.*, Basal membrane. *b. c.*, Buccal cavity. *b. ep.*, Basal epithelium. *b.g.*, Buccal ganglion. *b. gl.*, Buccal gland. *bl.*, Blastopore. *c. b. cn.*, Cerebro-buccal connective. *c. cm.*, Cerebral commissure. *c. g.*, Cerebral ganglion. *cl. c.*, Cleavage cavity. *co.*, Coelom. *col. musc.*, Columellar muscle. *c. p. cn.*, Cerebro-pedal connective. *c. pl. cn.*, Cerebro-pleural connective. *ct.*, Gill. *ct. f.*, Gill filament. *d. ep.*, Dorsal epithelium. *d. gl.*, Digestive gland. *dr.*, Dorsal side. *e.*, Eye. *ect.*, Ectoderm. *end.*, Endoderm. *f.*, Foot. *f. ep.*, Foot-epithelium. *g.*, gonad. *gl. c.*, Gland cells. *h.*, Heart. *h. ves.*, Head-vesicle. *i. c.*, Inner cornea. *i. i. cn.*, Infra-intestinal connective. *i. i. g.*, Infra-intestinal ganglion. *i. i. n.*, Infra-intestinal nerve. *int.*, Intestine. *int. g.*, Intestinal ganglion. *k.*, Right kidney. *k.*, Left (rudimentary) kidney. *l.*, Lung. *lens.*, Lens of eye. *l. h.*, Larval heart. *l. o.*, Opening of the lung. *lp.*, Lip. *l. r.*, Lung rudiment. *l. r. o.*, Opening of the lung rudiment. *lt. mes. bd.*, left mesoblastic band. *m.*, Mouth. *m. c.*, Mantle-cavity. *mes.*, Mesoderm. *mes. bd.*, mesoblastic band. *mesch.*, Mesenchyme cells. *mt.*, Mantle. *mtf.*, Mantle fold. *mt. gr.*, Mantle groove. *n.*, Nerve. *o. c.*, Outer cornea. *od.*, Odontoblasts. *oes.*, Oesophagus. *op.*, Operculum. *op. l.*, Operculigenous lobe. *op. n.*, Optic nerve. *os.*, Oosphradium. *os. n.*, Oosphradial nerve. *p.*, Right pericardium. *pl.*, Left pericardium. *p. cm.*,<sup>1</sup> First pedal commissure. *p. cm.*,<sup>2</sup> Second pedal commissure. *p. c. pl.*, Pedal cell-plate. *p. g.*, Pedal ganglion. *p. gl.*, Pedal gland. *p. gr.*, Pedal groove. *pl. g.*, Pleural ganglion. *pl. p. g.*, Pleuro-pedal ganglionic mass. *post.*, Posterior end. *p. r.*, Pericardial rudiment. *pr. st.*, Primitive stomach (or archenteron). *pr. tel.*, primary teloblasts or primary mesodermal cells. *p. r.*, Pulmonary vein. *q.*, Nuchal cells. *rad.*, Radula. *rad. s.*, Radular sac. *rad. t.*, Radular teeth. *ret.*, Retina. *r. p. o.*, Reno-pericardial aperture of the right kidney. *r.*,<sup>1</sup> *p. o.*, Reno-pericardial aperture of the left kidney. *rt. mes. bd.*, right mesoblastic band. *Sch. pl.*, Head plate or "Scheitelplatte." *seg. c.*, Segmentation cavity. *sept.*, Septum. *sh.*, Shell. *sh. gl.*, Shell gland. *s. i. g.*, Supra-intestinal ganglion. *s. i. n.*, Supra-intestinal nerve. *sinus.*, Blood sinus. *s. l. c.*, Sub-lingual cavity. *sl. gl.*, Salivary gland. *sl. gl. o.*, Opening of the salivary gland. *s. oes. p.*, Sub-oesophageal pouch. *s. rad. or.*, Sub-radular organ. *st.*, Stomach. *stat.*, Statocyst. *stomod.*, Stomodaeum. *str.*, Streak. *sup. m. r.*, Supra-marginal ridge. *t.*, Tentacle. *t. n.*, Tentacular nerve. *ur.*, Ureter of the Right kidney. *ur.*, Ureter of the left kidney. *v.*, Velum. *vac.*, Vacuoles. *vent.*, Ventricle. *vest.*, Vestibule. *v. g.*, Visceral ganglion. *v. h.*, Visceral hump. *v. m.*, Visceral sac. *v. p.*, Vegetable pole. *v. t.*, Ventral side.

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# ON THE LIFE-HISTORY OF A NEW GREGARINE, *GREBNECKIELLA*<sup>1</sup> *PIXELLAE*, SP. NOV., FROM THE CENTIPEDE, *SCOLOPENDRA MORSITANS* LINN., WITH A NOTE ON THE FAMILY DACTYLOPHORIDAE LÉGER, 1892.

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## INTRODUCTORY AND HISTORICAL.

Early in 1939 Prof. K. N. Bahl very kindly called my attention to the excellent contribution made by Pixell-Goodrich on "*Nina*, a remarkable gregarine", which she found in the gut of *Scolopendra cingulata* Latreille and *S. subspinipes* Leach, and suggested that I should work out the life-history of the gregarines occurring in *Scolopendra morsitans* Linn.,<sup>2</sup> which is the commonest centipede found at Lucknow (India). I may mention at once that *Scolopendra morsitans* harbours only one species of gregarine, i.e. *Grebneckiella pixellae*, sp. nov.; I have not been able to find any other gregarine during my examination extending over three years of the intestinal parasites of this centipede.

In 1873 Grebnecki described *Nina gracilis* (= *Pterocephalus nobilis* Sokolow, 1911) from *Scolopendra cingulata* Latr. (*S. cingulata* var.

<sup>1</sup> Synonyms: *Nina* Grebnecki, 1873 and *Pterocephalus* Aimé Schneider, 1887.

*Nina* was used as the generic name for a mollusc (Gray, 1850), while *Pterocephalus* had been used as the generic name for an elasmobranch fish (Swainson, 1838), a Nematode (Linstow, 1899), and a Trilobito (Raw, 1907), hence these names are inadmissible. But the generic name *Grebneckiella*, after Grebnecki, recently introduced by Bhatia (1938) is available and I have therefore adopted it in my paper.

<sup>2</sup> Identification of this centipede was made by Prof. K. N. Bahl and confirmed at the Indian Museum through kind courtesy of Dr. Baidi Prasad, Director, Zoological Survey of India, Calcutta.

*hispanica* Newp., vide Watson, 1916). Schneider (1887) recorded *Pterocephalus nobilis* from *Scolopendra morsitans* collected from Banyuls, but, according to Léger and Duboscq (1909) *Scolopendra cingulata* alone is found at Banyuls and not *Scolopendra morsitans*: Pixell-Goodrich (1938) also mentions that Schneider had wrongly named his *Scolopendra*. K  lliker (1848) described *Gregarina scolopendrae* from *Scolopendra morsitans* collected from Trieste, but Pixell-Goodrich has pointed out that he also was wrong in naming his centipede. According to her, K  lliker's centipede "may have been *Scolopendra cingulata*" but not *S. morsitans*, as this latter species has never been recorded from that locality. Labb   (1899) suggested that K  lliker's gregarine probably belonged to the genus *Pterocephalus* and not "*Gregarina*". Watson (1916), however, has rejected Labb  's suggestion and has asserted that from K  lliker's fig. 30 of *Gregarina scolopendrae* it appears that the protomerite is very different from that of *Nina*, and that since K  lliker had given no account of the epimerite of his gregarine it is impossible to say in which genus his specimen should be placed. In my opinion K  lliker's fig. 30 represents really a specimen of *Grebneekiella* with a contracted knob-like protomerite, a fact which has also been suggested by Pixell-Goodrich.

Since 1873 the following species of this genus have been recorded up to date: (1) *Pterocephalus giardi* L  ger, 1899, (= *Nina giardi* Sokolow, 1900) from *Scolopendra oraniensis* Verh. (2) *P. giardi corsicum* L  ger and Duboscq, 1903, (= *N. giardi corsicum* Sokolow, 1911) from *Scolopendra oraniensis lusitanica* Verh., (3) *Nina indica* Merton, 1911 from *Scolopendra subspinipes* Leach., and (4) *Nina navillae* Mitra and Chakravarty, 1937 from *Scolopendra* sp.

It would appear, therefore, that the gregarines described by various authors from *Scolopendra morsitans* are really not from this species but from other species of *Scolopendra*, and that *Scolopendra morsitans sensu stricto* has not been examined at all for gregarines. My observations on the only gregarine of *Scolopendra morsitans* have convinced me that it is specifically different from the hitherto described species of *Grebneekiella*, and therefore, I propose for it the name *Grebneekiella pixellae*, sp. nov., associating it with the name of Dr. Helen Pixell-Goodrich, M.A. (Oxon.), D.Sc. (Lond.), as a token of my appreciation for her remarkable observations on *Nina*(=*Grebneekiella*).

#### MATERIAL AND METHODS.

Specimens of *Scolopendra morsitans* were collected from beneath stones, bricks, etc., of old and neglected buildings in and around Lucknow, or flower pots in the University gardens. They were kept singly in wide glass jars with a fine wire-gauze cover. In summer they were kept in shade on moist earth under laboratory conditions, but in winter they were covered with straw and rags. Milk was the best diet to keep them alive for months together. At times they were fed on apples, carrots, etc. It was surprising to note that if this centipede was provided with tea it extruded several (many times more than the usual number of) gametocyts along with its faeces.

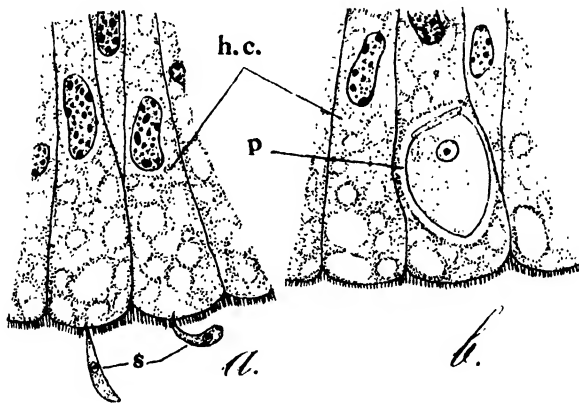
Pieces of the gut of *Scolopendra morsitans* were fixed in alcoholic Bouin, Schaudinn's fluid, and Gilson's mixture, sectioned at  $1\mu$  to  $6\mu$  and stained with iron-alum haematoxylin, Delafield's haematoxylin and eosin, and Mallory's triple stain. Gametocysts were fixed at various stages of development in warm Dobell's modification of Bouin (with a few drops of chloroform just before use) for 24 hours, sectioned at  $2\mu$  to  $4\mu$  and stained with iron-alum haematoxylin and orange-G or chromotrop 2 R. Total preparations and smears were fixed in warm Schaudinn's fluid, the former were stained with Delafield's haematoxylin and also borax carmine, while the latter were stained with iron-alum haematoxylin and at times counter-stained with chromotrop 2 R.

All drawings were made with the aid of a *Camera lucida* and magnification of the text-figures are given.

#### LIFE-HISTORY OF *GREBNECKIELLA PIXELLAE*, SP. NOV.

##### (a) Sporozoites and their development.

Fresh smears of live sporozoites obtained by rupturing mature spores in Ringer's solution under a coverglass, when examined under an oil-immersion lens, revealed that the sporozoites perform flexional movements followed by passive gliding movements when they become less energetic. Fixed and stained preparations showed that the sporozoites are spindle-shaped bodies measuring  $5\mu$  to  $7\mu$  in length. The cytoplasm of the sporozoites is homogeneous and the centrally located nucleus in each is of a vesicular type (Text-fig. 1a).



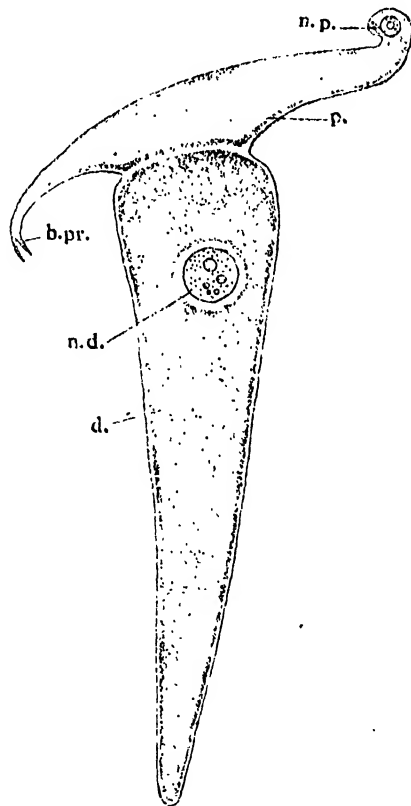
TEXT-FIG. 1.—*a.* Two sporozoites (*s*) attached to the epithelial cells (*h. c.*) of the host's gut:  $\times 2,386$ . *b.* A trophozoite (*p*) lying within the epithelial cell:  $\times 1,636$ .

The walls of the ingested spores are probably dissolved by the action of the gutfluid of *Scolopendra morsitans* and the sporozoites are liberated into the lumen of its gut and make their way towards the epithelial cells of the intestine to which they attach themselves. After penetrating these cells they are found to undergo an intra-cellular development (Text-fig. 1b). Later on, due to increased growth, the trophozoites, as they are now called, break through the intestinal cells and hang themselves into the lumen of the intestine while still remaining

attached by their epimerites to the epithelial lining. They grow in this situation till they attain maturity.

Pixell-Goodrich and all other previous workers have held that *Grebneckiella* leads an entirely extracellular existence, and they make no mention of an intracellular stage at all. My studies of the sections of fixed and stained material of the gut of *Scolopendra morsitans* have, however, convinced me that *Grebneckiella pixellae* passes through an intracellular phase during its development before it comes to the adult stage.

Pixell-Goodrich states, "Some of the young vegetative stages attain a considerable size before satisfactorily attaching themselves. . . Presumably, therefore, they can absorb food and grow while free in the lumen". In support of her statement she has sketched fig. 11c, Pl. 7 in her paper, but her figure represents, as far as I think, a contracted sporozoite rather than a "very young trophozoite". I have found several such instances



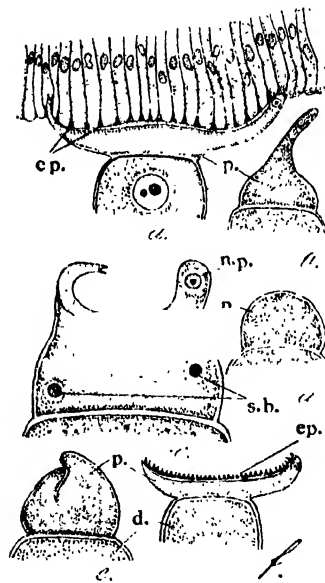
TEXT-FIG. 2.—A freshly detached adult specimen of *G. pixellae*: b. pr., bifid tip of the anucleated arm of the protomerite; n. d., deutomeritic nucleus; n. p., protomeritic nucleus; p., protomerite:  $\times 323$ .

of contracted sporozoites in the living condition. Further, the specimen represented by her fig. 1, Pl. 7 appears to me to have been previously attached, but having lost its epimerite in the epithelial cells had dropped

free into the lumen of the gut and due to the contraction of its protomerite looked as if it had never found an attachment. In fact, sporozoites of gregarines always at first attach themselves and then grow further. Pixell-Goodrich herself describes smaller individuals than the one shown in her fig. 1, Pl. 7 "firmly fixed to the gut wall with epimerites complete". It would appear, therefore, that the specimen which she regards as having "showed no signs of ever having been attached" to the gut-epithelium is really a later stage of *Grebneckiella* after its detachment.

(b) Trophozoites.

The youngest trophozoite that I have come across measures  $10.2\mu \times 6.6\mu$  in size (Text-fig. 1b). The protomerite is not very conspicuous inside the cell, and it is only after the parasite has come out of the cell that the protomerite expands and attaches itself to the free borders of several cells of the gut-epithelium (Text-fig. 3a). However, after



TEXT-FIG. 3.—a-f, Protomerite of *G. pixellae* in various shapes, d., deutomerite; ep., epimerites with filaments; n. p., protomeritic nucleus; p., protomerite; s. b., siderophilic bodies in the protomerite.  $\times 323$ .

this preliminary attachment the digitiform epimerite grows from the edge of the protomerite thereby affording a firm hold to the parasite.

A fresh smear of the gut of *Scolopendra morsitans* in Ringer's solution showed the parasites moving actively and the active movements performed by the protomerites, specially of the young and freshly detached cephalonts, being interesting to note. The protomerite shows



lateral contractions and expansions, as well as forward and backward movements. Due to its mobile nature it can assume various shapes. and at times the contractions are so strong that the protomerite is reduced to a mere knob-like elevation at the top of the deutomerite (Text-fig. 3 *a-c*). When the protomerite faces upwards, *i.e.* against the coverglass, its sucker-like appearance becomes very evident. The high degree of contractility of the protomerite is due to the presence of myonemes set along the free margin of the sucker. Pixell-Goodrich has mentioned that the protomerites of *Grebneckiella* could be "used as mobile suckers for attachment.....". As in *Echinomera* this is an exceptional instance of marked contractility of the protomerite amongst gregarines, and I agree with her remark that such an instance has never been "definitely stated before".

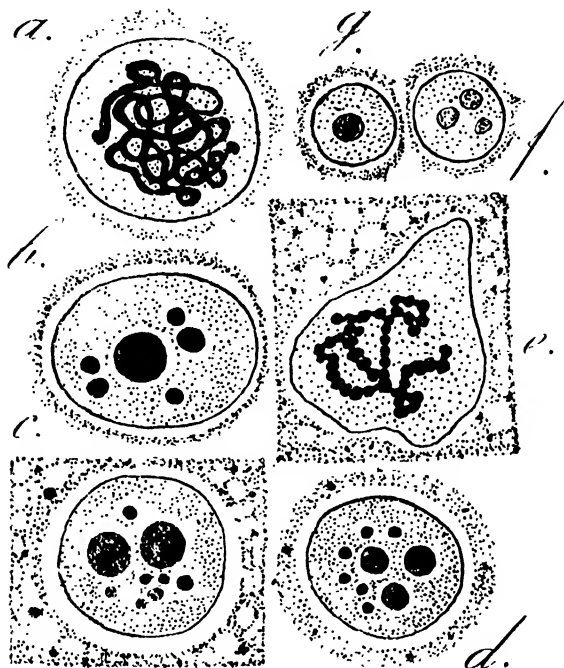
At times, however, it was also noticed that the protomerite of *Grebneckiella pixellae* pressed itself against the surface of the slide and that the deutomerite contracted postero-anteriorly resulting in the formation of convolutions on its surface. The deutomerite itself helps in movement and particularly comes into action when there is an impediment in front of the protomerite.

Fixed and stained preparations reveal that the epimerite of *Grebneckiella pixellae* is formed of several digitiform protuberances bearing thread-like filaments at their distal extremities (Text-fig. 3*a*). These protuberances stain black with iron-alum haematoxylin and, when deprived of their thread-like processes, appear as denticles beset on the edge of the protomerite (Text-fig. 3*f*). The epimerites are caducous, *i.e.* they are torn-off from the protomerite and are left behind in the epithelium when the trophozoites attain maturity and drop into the lumen of the gut.

In an extended condition the parasite presents a T-shaped appearance, the protomerite forming the cross-bar, one arm of which is definitely longer than the other, and the deutomerite forming the vertical limb (Text-fig. 2). In a detached individual the longer arm, which contains a small nucleus at its distal end is usually upturned, while the shorter arm, which is characterized by its bifid distal extremity, either curves posteriorly or is reduced to a knob. The cytoplasm of the protomerite is comparatively less dense than that of the deutomerite. The nucleus of the protomerite is vesicular and contains one to three chromatic bodies (Text-fig. 1*f, g*). This nucleus seems to have only a vegetative function and takes no part in the reproductive processes. At times I have noted, besides the nucleus, one or two siderophilous bodies in the protomerite of *Grebneckiella pixellae* (Text-fig. 3*e*). Their origin and function could not be determined.

The deutomerite is elongated: it is widest immediately behind the septum and gradually tapers posteriorly to a blunt end. But in young cephalonts the posterior end of the deutomerite is pointed. In a full grown individual it measures 3.050 $\mu$  in length and 90-6 $\mu$  in width at its maximum diameter. The pellicle is about 3 $\mu$  in thickness and the myocyte is very conspicuous. The cytoplasm of the deutomerite is very dense and highly granular, being replete with prominent granules which stain deep black with iron-alum haematoxylin.

~ The nucleus of the deutomerite is spherical or slightly ovoid in shape (Text-fig. 4 *b-d*) and, on an average, measures  $14.8\mu$  in diameter. It



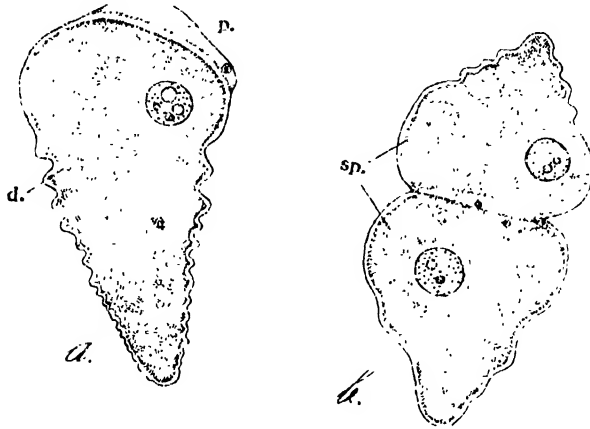
TEXT FIG. 4. *a, b*, Deutomeritic nucleus; *b, c* and *d* from whole mounts, and *a* and *b* from sections; *f* and *g*, protomeritic nucleus, from whole mounts:  $\times 600$ .

contains one to three big nucleoli and several small deeply staining granules; the nuclear membrane is distinct. Usually the nucleus is located anteriorly though it may be found in any region of the deutomerite. Merton (1911) has described and sketched the deutomerite nucleus of *Grebneckiella indica* as having a spireme of chromatin material—a statement not borne out by the description given by Léger and Duboscq (1909) for that of *G. gracilis*. Chakravarty (1938) has described the nucleus of *Grebneckiella navillae* as being spherical and having one karyosome and several small chromatin granules. Pixell-Goodrich has mentioned that the nucleus of *Grebneckiella* studied by her agreed with that of Léger and Duboscq's gregarine and certainly not with that of Merton's gregarine. The deutomerite nucleus of *Grebneckiella pixellae*, no doubt, resembles most that of *Grebneckiella gracilis*, but in some sporonts and various sections passing through the nucleus of *G. pierellae* the chromatin net-work (Text-fig. 4 *a, e*) was very apparent, indicating that the nucleus was ready for division. I think Merton has sketched the nucleus of one such sporont.

The body of *Grebneckiella pixellae* shows an apparent bilateral symmetry—the plane of symmetry passing between the bifids tips of the one arm and the distal extremity of the other arm along the long axis of the deutomerite. Ratio of the length of the protomerite to the total length L. P. : L. T. : : 1 : 15.23; width of the protomerite to that of the deutomerite W. P. : W. D. : : 1.2.2.5 : 1.

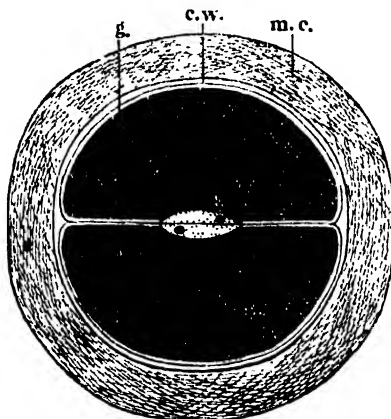
## (c) Sporonts and association.

Each sporont is characterized by having a reduced and laterally flexed protomerite (Text-fig. 5a) and by the absence of an epimerite. The



TEXT-FIG. 5.—a. A contracting sporont, from a fresh smear: p., protomerite; d. deutomerite:  $\times 190$ ; b. Two sporonts (sp.) in association:  $\times 190$  (Livespecimens).

cytoplasm is very dense and appears blue by reflected light and the deutomerite nucleus very often becomes masked in its substance. The sporonts show a passive gliding movement and are usually in a contracted condition. Two sporonts (gamonts) come together by their anterior ends with their protomerites lying opposed to each other (Text-fig. 5a). The deutomerites of the two gamonts contract further and further until at last they become rounded and secrete a common cyst-wall which later on becomes surrounded by a gelatinous covering  $60\mu$  to  $180\mu$  thick. The gametocysts thus formed measure  $208\mu$  to  $672\mu$  in diameter and are spherical in shape. The two protomerites



TEXT-FIG. 6.—A gametocyst of *G. pixellae*: m. c., mucous covering; c. w., cyst-wall, g. gamont:  $\times 70$ . (Live specimen stained with mucihaematin.)

at the place of their junction inside the freshly extruded cysts appear like a hollow biconvex lens under the coverglass (Text-fig. 6). The highly hygroscopic gelatinous layer is composed of numerous concentric layers, each layer probably indicating the quantity of the exudate oozing out of the body of the rounded up gamonts at one time. Various mucous stains, as suggested by Pixell-Goodrich, were tried but the cyst-wall proper did not take up these stains and according to her possibly it is made up of keratin. The cyst-wall is comparatively tense and offers more resistance to various infections (bacteria, fungi, etc.) than does the gelatinous layer. In fact, I have not encountered the mycelial infection (*Mucoridæ* ?) inside the cysts as described by Léger and Duboscq and also by Pixell-Goodrich, although such infections were of frequent occurrence in the gelatinous layer.

Encystment of single individuals has also been noted but very little mucus is secreted in such cases and such individuals ultimately degenerate.

Healthy cysts were frequently found outside the peritrophic membrane, but they were also found within it, hence, it does not seem to be "a rule", as mentioned by Pixell-Goodrich, that they are always external to this membrane. As regards the condition of freshly extruded cysts I agree with Léger and Duboscq's statement that such cysts are normally in an advanced stage of development, as the deutomerite nuclei of hundreds of fresh cysts of *Grebneckiella pixellae* were found to have already started dividing. Pixell-Goodrich has contradicted these authors and holds that freshly extruded cysts of her gregarine had "unchanged deutomerite nucleus".

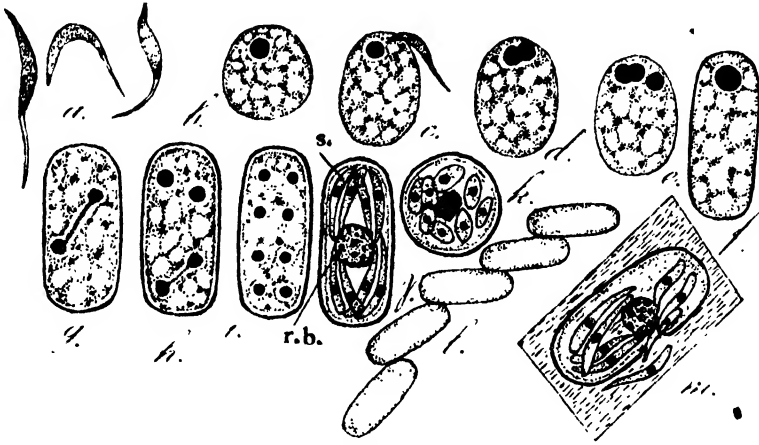
Autopsy of several specimens of *Scolopendra morsitans* revealed that cysts in the intestine had their nuclei unchanged but such cysts when "cultured" in hanging drops had their nuclei dissolved (divided) within one to three days. The fact that in the faecal matter the nuclei were generally found dissolved shows that it probably takes one to three days for the cysts to pass from the intestine to the exterior.

#### (d) Gamete-formation and structure of the gametes.

The stages of nuclear division and gamete-formation studied from the sections of the gametocysts of *Grebneckiella pixellae* resemble those of *Grebneckiella gracilis*, as described and sketched by Léger and Duboscq (1909), and it is therefore unnecessary to describe them again. The haploid number of chromosomes is undoubtedly five, four of which are equal, being in two pairs, while one is extraordinarily long and unpaired and which ultimately forms the karyosome. Chakravarty (1938), has mentioned that the haploid number of chromosomes of *Grebneckiella navillae* is only two and that there is no axial (unpaired) chromosome.

The microgametes when examined alive under an oil-immersion lens showed marked agility, and fixed and stained preparations revealed that they are minute filamentous bodies measuring  $5\mu$  to  $6\mu$  in length. Each microgamete (Text-fig. 7a) consists of an elongated head or rostrum composed almost entirely of chromatin material and a drawn-out tail or flagellum which helps in its movement. At the apex of the head there is a small refringent granule. The undulating membrane, which,

according to Minchin (1903). "runs in a loose spiral from the rostrum to the base of the flagellum" could not be detected in my preparations.



TEXT-FIG. 7.—*a*. A microgamete.  $\times 4,184$ ; *b*. a macrogamete; *c*. showing entrance of a microgamete into a macrogamete; *d*. pro-zygote stage; *e*. a macrogamete showing three nuclei, presumably by the entrance of two microgametes; *f*. a zygote; *g*. spores showing nuclear division and formation of sporozoites; note the residual body (*r. b.*) in *j*; *k*. an abnormal spore: *b-k*  $\times 2,272$ ; *l*. a chain of spores attached obliquely,  $\times 1,270$ ; *m*. a mature spore showing liberation of spores in Ringer's solution.  $\times 2,272$ . (*l* and *m*. Live specimens.)

The macrogametes are non-motile, spherical bodies measuring  $7\mu$  to  $9\mu$  in diameter (Text-fig. 7*b*), but after attaining maturity they tend to become oval, so much so that they assume a, more or less, cylindrical shape either after fertilization or even before it (Text-fig. 7*c-e*). Each macrogamete has an excentrically located nucleus,  $1.6\mu$  in diameter, and its cytoplasm contains prominent reserve granules. In appearance the macrogametes resemble the telolecithal ova of Metazoa as mentioned by Minchin. It would appear, therefore, that the gametes of *Grebneciella* present a striking instance of anisogamy among this group of Protozoa.

#### (c) Fertilization and spore-formation.

It is held that minute apertures (never detected by me) are present in the partition membrane separating the two gamonts in the cyst and it is through these apertures that the microgametes escape from the male chamber into the female chamber where they fertilize the macrogametes. Microscopical examination of live gametes obtained by puncturing the cysts in Ringer's solution revealed that the microgamete is attracted towards that end of the macrogamete which contains the nucleus (Text-fig. 7*c*). After penetration the nucleus of the microgamete reaches that of the macrogamete, abuts against it, rests for some time (pro-zygote stage Text-fig. 7*d*) and then fuses with it to form the zygote nucleus (Text-fig. 7*f*). On a few occasions I have noted two nuclei besides the definitive female nucleus within the macrogamete (Text-fig. 7*e*). This is probably due to the entrance of two microgametes inside a macrogamete. The whole process after the entrance of the male nucleus

till the formation of the zygote nucleus takes about twenty minutes to one hour or at times even longer. The zygote elongates, becomes cylindrical, secretes a wall around it and thus forms a spore. The spores when liberated during the dehiscence of the cysts remain attached together in oblique chains (Text-fig. 7l): this adherence is brought about by the presence of an oily film around each spore.

(f) Structure of the spores and formation of the sporozoites.

The spores are cylindrical bodies measuring  $10\mu$  to  $13\mu$  in length and  $4\mu$  to  $5\mu$  in width, the most frequent measurements being  $11\mu \times 4\mu$ . Each spore has an excentrically located nucleus and its cytoplasm contains refringent granules. The sporocystic wall consists of two layers: an inner layer, the endospore, which is thin and delicate, and an outer layer, the epispore, which is thick and resistant. There is no operculum in the spores of *Grebneekiella pixellae* and the liberation of sporozoites takes place by the dissolution or rupture of the wall of the spores. In this respect the spores of *G. pixellae* differ from those of *Grebneekiella gracilis* described by Pixell-Goodrich. Moreover, she has given a period of over one year as the duration of viability of the spores of her gregarine, but in *G. pixellae* I have found that the spores are viable only for three to four months. I have found a few spores which were rounded and which had oval sporozoites (Text-fig. 7k), but such rounded spores were very rare and may be regarded as abnormal.

The nucleus of each spore divides into eight daughter nuclei by three successive divisions and its cytoplasm segments around each nucleus thus giving rise to eight sporozoites which are arranged in two tiers (Text-fig. 7g-j). A definite residual cytoplasm consisting of refringent granules is left in the centre of the spore after the formation of the sporozoites. The whole process takes about 24 to 48 hours. Léger and Duboscq (1909), as mentioned by Pixell-Goodrich, have given  $10\mu$  to  $11\mu$  as the length of the sporozoites, whereas she has given  $5\mu$  to  $6\mu$ , maximum being  $8\mu$ , as the length of the sporozoites of *Grebneekiella gracilis*, and has mentioned that the sporozoites are about half the length of the spores. The measurements of the sporozoites of *Grebneekiella pixellae* approximate those given by Pixell-Goodrich. To my mind it appears that Léger and Duboscq measured the lengths of two sporozoites lying tandem. Usually the sporozoites of *G. pixellae* remain slightly curved inside the spore, and hence appear approximately to be half the length of the spore, but in an extended condition they are somewhat longer, as can be noticed by examining the live mature spores in Ringer's solution in which they often rupture.

(g) Remarkable stages in the developing cysts.

I have verified Pixell-Goodrich's observations on the developing cysts, stage by stage, and have found that my observations on the developing cysts of *Grebneekiella pixellae* agree with those described by her for the cysts of *Grebneekiella gracilis*. In hanging drops the whole process from the time of freshly extruded cysts till the liberation of spores takes 4 to 7 days. It may be remarked that at times the cysts

did not rise to the surface of the water and the spores were liberated within the water: presumably all the stages were gone through under water. Cysts kept in moist chamber but not actually within water also dehiscenced and liberated their spores. It seems probable that in the natural habitat of *Scolopendra morsitans* where only the moisture of the earth under stones, etc., is available, excepting during the rains, dehiscence of spores takes place in the usual way, i.e. by pseudocyst-formation, but the stages A, B and C as described by Pixell-Goodrich are not so well marked owing to insufficiency of water for the cysts to float upon.

#### (h) Mode of infection.

Infection is carried on from host to host through food and drink contaminated with infective spores and is more common in the adults than in young specimens. The maximum site of infection is just behind the proventriculus and at times the gregarines seem to block the lumen of the gut.

#### DIAGNOSIS OF *GREBNECKIELLA PIXELLAE*, SP. NOV.

Sporonts solitary, measuring  $1050\mu$  to  $1050\mu$  in length: epimerite caducons, digitiform, with filaments: protomerite a mobile sucker, with two asymmetrical arms, one longer and nucleated, the other shorter, annuleated and bifid: bilaterally symmetrical: deutomerite elongated, widest behind the septum, terminates in blunt end: L. P.: L. T.: 1: 15.23: W. P.: W. D.: 1.2-2.5: 1: cysts spherical, measuring  $208\mu$  to  $672\mu$ : dehiscence by pseudocyst: spore: cylindrical or long ovoidal, with two envelopes, united in oblique chains, measuring  $10\mu$  to  $13\mu \times 4\mu$  to  $5\mu$ : operculum absent in spores.

*Habitat.*—Mid-gut of *Scolopendra morsitans* Linn.

*Locality.*—Lucknow, U. P., India.

#### NOTE ON THE FAMILY DACTYLOPHORIDAE.

The family Dactylophoridae Léger, 1892, of seprate gregarines seems to have been loosely handled by protozoologists and "requires revision", as has been pertinently remarked by Pixell-Goodrich (1938). A perusal of the relevant literature shows that the definition of this family as given by Pixell-Goodrich is most plausible, but it would be complete were it added that sporonts are solitary and that dehiscence of cysts take place by simple rupture as well (*vide* Bhatia, 1938, p. 108).

Majority of the authors have included in this family the gregarines occurring in the gut of Chilopoda alone, but Kudo (1939) has included in it the gregarines occurring in the gut of other animals as well (*vide infra*), although while defining the family he mentions that its representatives occur "in guts of chilopods".<sup>1</sup> He has placed the following genera under the family Dactylophoridae: (1) *Dactylophorus* Balbiani, (2) *Echinomera* Labbé, (3) *Rhopalonia* Léger, (4) *Dendrorhynchus* Keilin, (5) *Trichorhynchus* Schneider, (6) *Nina* (= *Grebneckiella*) Grebnecki, (7) *Seticephalus* Kamm, (8) *Acutispora* Crawley, (9) *Metamera* Duke,

<sup>1</sup> Italics are mine.

(10) *Hentschelia* Mackinnon and Ray, (11) *Lecythion* Mackinnon and Ray. Firstly, it may be pointed out that out of these eleven genera, the following four genera occur in such hosts as do not belong to the order Chilopoda : (i) *Dendrorhynchus systemi* Keilin, occurs in the mid-gut of the larvae of *Systemus* sp., which is an insect (Dolichopodidae, Diptera). (ii) *Metanera schubergi* Duke, occurs in the gut of *Glossiphonia campanata* and *Placobdella marginata*, which are leeches (Glossiphoniidae, Rhynchobdellidae, Hirudinea), while (iii) *Hentschelia thalassemae* and (iv) *Lecythion thalassemae* Mackinnon and Ray, occur in the gut of *Thalassema neptuni*, which is an Echiurid worm. Secondly, it may be noted that while classifying the *Cephalina* (Eggregarinida, Gregarinida, Telosporidia) Kudo has defined the family Dactylophoridae along with others, as having characteristic extracellular development to distinguish them from the two families, Cephaloidophoridae and Stenophoridae, which are characterized by intracellular development. I have already emphasized that *Grebneckiella pixellae* passes through an intracellular phase of development during its early stages. Further, there are two other genera, namely, *Hentschelia* and *Lecythion*, which Kudo characterizes as those with extracellular development. For example, Mackinnon and Ray (1931, p. 451) write about *Hentschelia thalassemae*, "We have found a few young stages. These lie *within* the epithelial cells (fig. 14, Pl. 20)". Moreover, they have also mentioned (pp. 460-461) that "*Doliocystis* (*Leculina* ?) and *Hentschelia* are *intracellular*<sup>2</sup> in the early stages of their life within the gut, and their epimeritic segment always remains intracellular". As regards *Lecythion thalassemae*, although Mackinnon and Ray have sketched its intracellular stage (*vide* their fig. 20, Pl. 20), they doubt the intracellular development of this parasite, as is evident from the question mark in connection with the explanation of that figure (p. 465), and from their statement (p. 454) that "in the adult condition, anyhow, it is never intracellular". In fact, there are several gregarines which show an intracellular growth during the early developmental stages but are entirely extracellular in the adult condition. It is possible that this is the case with *Lecythion*, although Mackinnon and Ray have not met with the intracellular stage. From these facts it would appear that at least two genera, namely, *Hentschelia* and *Grebneckiella*, and possibly also *Lecythion*, as exemplified by *H. thalassemae*, *G. pixellae* and *L. thalassemae* respectively, should be included in a family of the *Cephalina* whose members exhibit intracellular development, or, if they are to be included within the family Dactylophoridae, this family should not be characterized by having its "Development extracellular" as given by Kudo. For the present it would be better if the family Dactylophoridae were to be placed between those families of the *Cephalina* whose members exhibit intracellular development and those whose members develop entirely extracellularly. Finally, it may be mentioned that the whole family needs revision and its exact position amongst the septate gregarines needs to be accurately determined.

<sup>1</sup> Duke in her original paper (*Quart. Journ. Micros. Sci.*, 1910, Vol. LV, pp. 261-286) mentions *Hemiclepsis* instead of *Placobdella*.

<sup>2</sup> Italics are mine.



## SUMMARY.

(1) A new gregarine, *Grebneckiella pixellae*, sp. nov., is recorded from *Scolopendra morsitans* Linn.

(2) This gregarine passes through an intracellular phase of development before attaining maturity.

(3) Various points dealing with the developing cysts, as described by H. Pixell-Goodrich (1938) for *Nina gracilis* Grebnecki, 1873, have been verified.

(4) The present position of the family Dactylophoridae Léger, 1892, has been discussed and it is concluded that its exact position amongst the septate gregarines requires to be accurately determined.

## ACKNOWLEDGMENTS.

It is a pleasure to express my most sincere thanks to Prof. K. N. Bahl, D.Sc. (Punj.), D. Phil., D.Sc. (Oxon.), F.R.A.S.B., F.N.I., for his kind guidance, confirmation of my observations, and painstaking correction of this manuscript. My sincere thanks are also due to Dr. B. Prashad, O.B.E., D.Sc. (Punj.), D.Sc. (Edinb.), F.R.S.E., F.L.S., F.Z.S., F.R.A.S.B., F.N.I., for very kindly reading through the manuscript and for help in its preparation.

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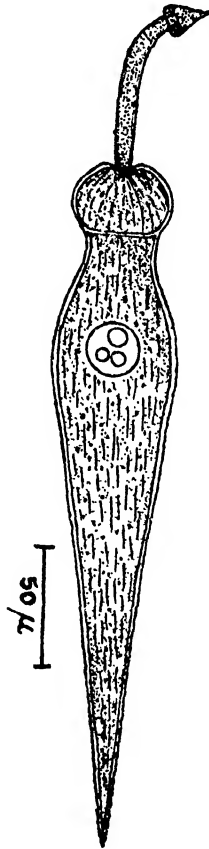
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A NEW GREGARINE, *STYLOCEPHALUS INDICUS*, SP. NOV. FROM  
A BETTLE.

By P. L. MISRA, Zoological Research Laboratory, University of Lucknow.

*Description.*—Sporonts solitary, elongate,  $320\mu$  to  $460\mu$  in length, maximum length  $490\mu$ ; epimerite a long style, more than twice the length of the protomerite, with a crown-like hood at its distal end; protomerite subspherical, with prominent longitudinal myonemic fibres, retractile; deutomerite elongate, widest a little behind the septum,



An adult specimen of *Stylocephalus indicus*, sp. nov.

tapers to a sharp pointed extremity; endocyte dense, with big granules; nucleus spherical,  $20\mu$  to  $26.3\mu$  in diameter, with 1 to 3 nucleoli; L.'P. : L. T. : : 1 : 6-9; W. P. : W. D. : : 1 : 1.1-1.4; cysts spherical, beset

with indentations and papillae,  $150\mu$  to  $182\mu$  in diameter ; spores broad spindle-like in front view, concave in profile, brown, measure  $7.5\mu \times 5.8\mu$ .

*Systematic position.*—*Stylocephalus indicus*, sp. nov. (Stylocephalidae, Eugregarinida.)

*Habitat.*—Mid-gut of *Opatroides (Penthicus) vicinis* Frm. (Coleoptera).

*Locality.*—Lucknow, U. P., India.

[For literature, material and methods. *vide* Misra, P. L. (1941).—Observations on a new gregarine, *Stylocephalus bahli*, sp. nov. from the alimentary canal of an Indian beetle, *Gonocephalum helopioides* Frm. *Rec. Ind. Mus.*, Vol. XLIII, pp. 43-71.]

## CRUSTACÉS DE L'ETAT DE DJODHPOUR (RADJPOUTANA).

Par KNUT LINDBERG.

Ayant appris la fréquence de la draconculose dans certaines contrées de l'Etat de Djodhpour, il m'a semblé pouvoir offrir de l'intérêt à les visiter, pour voir ce en quoi les conditions épidémiologiques locales pouvaient différer de celles régnant ailleurs dans l'Inde. Une courte visite a conséquemment été faite au début du mois d'avril à Nagaur et à Didvana, qui sont, d'après les statistiques officielles, les deux villes les plus affectées. Dans cet article il est question exclusivement de la faune des réservoirs d'eau que j'ai eu l'occasion d'examiner.

Les régions parcourues contrastent fortement avec celles du Deccan et du Sud de l'Inde, où sévit la même affection. Les plaines sablonneuses aux alentours de Nagaur et de Didvana, bien qu'arides, sont verdoyantes et régulièrement boisées (surtout par *Prosopis spicigera*). et sous les arbres croissent une multitude de plantes épineuses (principalement *Capparis aphylla*, *Orphanthera viminia* et *Zizyphus*).

A Nagaur la couche de sable a une profondeur d'environ 75 centimètres et recouvre une forte assise de poudingue, qui à son tour repose sur le grès primitif. L'eau de pluie s'accumule dans un grand nombre de dépressions naturelles situées à la périphérie de la ville, où le sable fait défaut et le sol est formé, soit d'un agrégat compact de cailloux et de terre, soit de bancs de calcaire. A ces derniers endroits (étang Guinani) l'eau conserve sa douceur et reste presque toujours en quantité suffisante jusqu'à la mousson de l'année prochaine. Ailleurs, où la terre est plus perméable, l'eau devient légèrement saumâtre, et ces autres rassemblements d'eau de surface peuvent se dessécher entièrement pendant la saison chaude, tandis que les puits, creusés au milieu des mêmes dépressions ou dans leur voisinage, contiennent en général de l'eau un peu saline, mais potable, pendant toute l'année. L'accès aux étangs est libre de tous côtés; hommes et bêtes descendent dans l'eau pour boire et faire des ablutions et leurs déjections s'y mélangent.

L'étang Guinani est le réservoir d'eau principal de la ville. Assez extensif, et à plusieurs embranchements suivant le terrain, il contenait une quantité considérable d'eau, dont la profondeur semblait dépasser un mètre et demi à certains endroits. De caractère oligotrophique d'une façon générale, l'eau renfermait cependant par places des touffes importantes de plantes aquatiques submergées (notamment *Potamogeton crispus*).

Plusieurs spécimens furent prélevés à des lieux et à des niveaux différents, tant le matin que le soir. Les Cyclopidés étaient très peu nombreux, par rapport à la grande quantité d'eau passée à travers le filet, et se trouvaient surtout là où manquait toute végétation et où s'abreuyaient de préférence les hommes et les animaux. Les Centropagides abondaient et à deux endroits il y avait d'assez nombreux Cladocères. Leur fréquence relative, comparée à celle des Cyclopidés, variait de 10 à 50 Centropagides et de 0 à 30 Cladocères pour chaque

Cyclopide. La totalité de ces derniers que renfermaient les neuf échantillons fut examinée.

Le Djhalra du tombeau du Soufi, près de l'étang Guinani, est un puits percé dans le roc calcaire dont on a fait sauter les parois d'un côté, aménageant ainsi une rampe par où la descente se fait aisément jusqu'au niveau de l'eau, mais où les bêtes ne s'aventurent guère à cause de la raideur de la pente.

Les deux spécimens récoltés étaient extraordinairement riches en Crustacés, ceux-ci formant presque une masse semi-solide. Les Cyclopidés y étaient nombreux, mais c'était les Cladocères qui prédominaient. Il y en avait environ 50 par Cyclopide. J'ai compté une moyenne de un Centropagide pour 200 Cladocères. L'eau de ce puits était bourbeuse mais abondante et il n'y avait aucune végétation aquatique visible. Du total récolté probablement moins qu'une millième partie fut examinée.

Étang Samach. A l'époque des pluies le bas-fond étendu qui porte ce nom est sans doute rempli par une nappe d'eau continue. Au moment de ma visite il n'y avait là que quelques mares isolées, peu profondes et différant de caractère les unes des autres. Des spécimens d'eau de deux de ces petits étangs furent pris. Dans les deux il y avait une forte prépondérance des Cyclopidés sur les autres Crustacés et parmi ceux-là les *Microcyclops* formaient la majorité, ce qui est peu commun dans ce genre de biotopes. L'un des échantillons, dont environ une cinquantième partie fut examinée, contenait en moyenne un Centropagide pour 40 Cyclopidés, un Cladocère pour 30 Cyclopidés et quelques rares Ostracodes. De l'autre, moins riche, la moitié du matériel récolté fut étudiée; celle-ci renfermait de très nombreux Cladocères jeunes, quelques rares adultes et un petit nombre de Centropagides.

L'eau du puits situé sur le bord de l'étang principal de Samach avait une profondeur de 5 mètres et demi. Le sédiment entier pêché du fond fut examiné. Il montrait également des *Microcyclops* plus nombreux que les *Mesocyclops*; le nombre total des Centropagides était de 20 et celui des Cladocères de 2.

A Lal Sagar l'eau de pluie remplit une grande fosse profonde dont le fond semble être rocheux. L'eau en est fort trouble et il n'y a aucune végétation macroscopique. Tout le matériel récolté fut examiné; il contenait environ 75 Centropagides. Il y a là aussi un puits.

L'étang de Djhara était en voie de dessèchement et l'eau, fortement chargée de boue, ne montrait dans le spécimen récolté qu'un petit nombre de *Mesocyclops*, 8 Centropagides et un jeune Cladocère.

La vaste dépression de Pratap Sagar était entièrement à sec mais les puits, dont j'ai compté 13, semblaient tous tenir de l'eau en quantité appréciable. Dans le spécimen retiré du fond de l'un deux et examiné en son entier, il y avait une prépondérance marquée des Cladocères, dont j'ai compte une moyenne de 300 pour chaque Cyclopide.

L'étang de Bag Sagar n'a pas été visité, ni le Sakar talab, situé en dehors de la ville.

La liste des Cyclopidés identifiés des 17 échantillons de Nagaur est donnée à la fin; pour économiser de l'espace les 9 spécimens de l'étang Guinani et les 2 du puits du Soufi n'ont pas été détaillés séparément.

Aucun des 2801 Cyclopidés examinés de Nagaur n'a été trouvé infesté par les embryons du ver de Médine, ni par d'autres nématodes.

*Didvana.* Dans le voisinage de la ville il y a des étendues de surface constituées de glaise sableuse d'une épaisseur de 60 à 90 centimètres, cette couche recouvrant le poudingue usuel. L'eau se réunit dans un certain nombre de bas-fonds naturels qui existent en dehors de la partie habitée, mais elle s'épuise rapidement partout, sauf dans deux grandes dépressions assez profondes au nord-est de l'agglomération (Katchora et Sekh), et dans une large cuvette argileuse au sud-ouest (étang Singui), où des canaux ont été creusés pour en augmenter la capacité.

Les étangs au nord-est de la ville, dont on compte 3 (Tchila ou Katchora, Sekh et Béni), étaient à sec depuis déjà trois ou quatre mois au moment de ma visite. Les autres, situés au sud et au sud-ouest (Sédolai, Dhoutolai, Bibolai, Télolai, Singui, et Indolav, rangés selon leur proximité de la ville), étaient également desséchés, sauf l'étang Singui, qui, on peut dire, constituait à l'époque de mon voyage l'unique réservoir d'eau de boisson de la population. La circonférence du petit étang presque circulaire était d'environ 300 mètres, et on m'a dit que sa profondeur atteignait au centre à peu près un mètre et demi. L'eau en était trouble, d'une odeur désagréable et uniformément verte, cette coloration n'étant cependant pas causée par des algues, comme je n'en ai pas vu à l'examen microscopique. Six échantillons en furent récoltés à des endroits différents, le matin et le soir. Les sédiments étaient très abondants et à peu près une deux centième partie en fut examinée. Ils renfermaient presque exclusivement des *Mesocyclops leuckarti*; j'ai compté un total de moins de 50 Centropagides et seulement 5 ou 6 Cladocères. Un copépode de *M. leuckarti* fut trouvé infesté par un embryon de *Dracunculus medinensis*, l'unique Cyclopide parasité par ce ver sur 1113 examinés provenant de Didvana. Il est cependant, possible que quelques animaux infestés aient pu échapper à la découverte comme les larves sont parfois malaisées à voir à l'état de mort à l'intérieur de hôtes fortement pigmentés.

Il existe aussi d'assez nombreux puits près de la ville; aucun semble tenir de l'eau douce, mais la salinité de plusieurs d'entre eux est si faible que l'eau en est potable. A l'est des habitations se trouvent 14 puits (Tchanankoï) qui semblaient de construction récente. Au fond de la plupart il n'y avait que du limon humide et dans les autres, dont l'eau pouvait se boire, elle ne montait que de quelques centimètres. Dans un puits situé près de la déclivité menant au lac salin de Didvana (actuellement desséché) la hauteur de l'eau était de deux mètres; elle était fortement saumâtre et utilisée pour le bétail. La profondeur des puits examinés, variait de 13 à 16 mètres. Selon un informateur du pays l'eau peut atteindre un maximum de 13 coudées (environ 6 mètres et demi) dans l'un des puits, mais seulement 4 coudées (environ 2 mètres) dans tous les autres. L'eau de 5 puits fut examinée, mais des Cyclopidés ne furent trouvés que dans deux d'entre eux.

A Didvana, comme du reste aussi à Nagaur, un très petit nombre de commerçants possèdent une citerne dans leurs maisons pour recueillir de l'eau de pluie. Il y en a aussi dans certains temples, mosquées



et chaudières, mais l'usage de ce genre de réservoir est extrêmement restreint dans les deux villes.

Un habitant, pourtant intelligent, semblait vouloir caractériser en ces mots une situation qu'apparemment il jugeait sans remède :

“ Nous avons des roupies (de l'argent), mais nous n'avons pas d'eau ”.

D'après ce qui a été dit on voit qu'en fait de vecteurs il ne peut être question que de *Mesocyclops leuckarti*, *Thermocyclops hyalinus* et *Microcyclops varicans*. Les deux premiers sont des hôtes avérés ailleurs dans l'Inde et tout porte à croire qu'ils sont responsables de la transmission de la maladie aussi à Nagaur, tandis qu'à Didvana il ne peut évidemment s'agir que de *Mesocyclops leuckarti*, en admettant qu'aucune autre espèce ne fasse son apparition en nombre suffisant à une époque plus avancée de la saison. Il a déjà été mentionné qu'un copépodite de *Mesocyclops leuckarti*, pêché dans l'étang Singui (le 7 avril 1942), fut trouvé infesté par un embryon de *Dracunculus medinensis*. Celui-ci avait une longueur de 434 $\mu$  et une largeur de 25 $\mu$  au milieu du corps. Quant à *Microcyclops varicans*, sa présence dans les puits ou autres réservoirs d'eau servant de gîtes au parasite de la draconculose est plutôt exceptionnelle dans l'Inde et, semble-t-il, aussi ailleurs dans le monde, où la maladie est endémique ; et quand on le rencontre, c'est le plus souvent en petit nombre. Aussi sa découverte dans l'étang Samach à Nagaur en grand nombre et y formant même la majorité des Cyclopides est un fait très remarquable, et il serait bien intéressant de rechercher dans cet étang pendant un temps suffisant si ce cyclope y présente de l'infestation naturelle par le ver de Médine. A l'heure actuelle on ne peut rien dire à ce sujet.

La liste des Cyclopides des 10 échantillons récoltés à Didvana est donnée ci-après ; ceux de l'étang Singui étant réunis sous un seul tête. Deux espèces de cyclopes seulement furent trouvées. Les quelques *Microcyclops* récoltés étaient tous des copépodites et appartenaient évidemment à une même espèce. Il n'était pas possible de les identifier d'une manière certaine. Ils ressemblaient à *Microcyclops moghulensis* Lindberg.

#### NAGAU.

##### Etang Guinani

*Microcyclops varicans* Sars. ♂♂ 35,  
jeune 1.

*Microcyclops linjanticus* Kiefer. ♀ 1.

*Mesocyclops leuckarti* Claus. ♂♀  
126, ♂♂ 38, jeunes 127.

*Thermocyclops hyalinus* (Rehberg).  
♀♀ 40, ♂ 1, jeunes 2.

Puits à marches près du santan du  
Soufi (Djhalra Soufi ka dergah).

*Mesocyclops leuckarti* Claus. ♂♀ 62,  
♂♂ 19, jeunes 91.

*Thermocyclops hyalinus* (Rehberg).  
♀♀ 140, ♂♂ 8, jeunes 22.

##### Etang Samach I.

*Microcyclops varicans* Sars. ♀♀ 170,  
♂ 1, jeunes 25.

*Microcyclops linjanticus* Kiefer. ♀ 1,  
jeune 1.

*Mesocyclops leuckarti* Claus. ♀♀ 51,  
♂♂ 11, jeunes 36.

*Thermocyclops hyalinus* (Rehberg).  
♀♀ 48, jeunes 18.

##### Etang Samach II.

*Mesocyclops varicans* Sars. ♀♀ 453,  
♂♂ 10, jeunes 196.

*Mesocyclops leuckarti* Claus. ♂♀ 65,  
♂♂ 14, jeunes 63.

*Thermocyclops hyalinus* (Rehberg).  
♀♀ 3, jeunes 2.

NAGAU—*contd.*

Puits à l'étang Samach.

*Microcyclops varicans* Sars. ♀♀ 17.  
jeunes 2.*Mesocyclops leuckarti* Claus. ♀♀ 2  
jeunes 4.*Thermocyclops hyalinus* (Rehberg).  
♀♀ 2, jeunes 2.

Étang Lalsagar ("Mer rouge").

*Microcyclops varicans* Sars. ♀♀ 2.*Mesocyclops leuckarti* Claus. ♀♀ 338,  
♂♂ 158, jeunes 213.*Thermocyclops hyalinus* (Rehberg).  
♀ 1.

Étang Djhara.

*Mesocyclops leuckarti* Claus. ♀♀ 27,  
♂♂ 5, jeunes 15.

Puits à l'étang Pratap Sagar.

*Microcyclops varicans* Sars. Jeune 1.*Mesocyclops leuckarti* Claus. ♀♀ 11,  
♂♂ 4, jeunes 3.*Thermocyclops hyalinus* (Rehberg).  
♀♀ 95, ♂ 1, jeunes 8.

## DIDVANA.

Étang Singui

*Microcyclops* sp. Jeunes 14.*Mesocyclops leuckarti* Claus. ♀♀  
277, ♂♂ 276, jeunes 513.

Puits à l'eau légèrement saumâtre.

*Microcyclops* sp. Jeunes 2.*Mesocyclops leuckarti* Claus. ♀♀ 2,  
jeunes 9.

Puits à l'eau salino.

*Mesocyclops leuckarti* Claus. Jeunes 2.

Citerne d'un puits à l'eau salino.

*Mesocyclops leuckarti* Claus. ♀♀ 4,  
♂ 1, jeunes 5.Citerne à l'eau douce dans un dharam-  
chala*Mesocyclops leuckarti* Claus. ♀♀ 2,  
♂♂ 2, jeunes 4.

J'ai le devoir agréable de remercier très vivement aussi ici M. le docteur Madan, médecin en chef de l'État de Djodhpour, pour les statistiques qu'il a eu la grande amabilité de me fournir, M. F. F. Fergusson, ingénieur en chef, pour sa grande obligeance de me donner des renseignements géologiques, et M. le docteur K. Biswas pour l'identification d'une plante aquatique.

## SOMMAIRE.

Cinq espèces de Cyclopides furent trouvées dans des étangs, des puits et des citernes à Nagaur et à Didvana (État de Djodhpour) : *Microcyclops varicans* Sars, *Microcyclops linjanticus* Kiefer, *Microcyclops* sp. (Copépodites seulement), *Mesocyclops leuckarti* Claus. *Mesocyclops hyalinus* (Rehberg).

Un copépodite de *Mesocyclops leuckarti* Claus, récolté début avril dans un étang à Didvana, fut trouvé infesté par un embryon de *Dracunculus medinensis*.

La proportion numérique des autres Crustacés par rapport à celle des Cyclopides a été indiquée d'une façon approximative.

Dans les deux localités la majorité de la population boit l'eau de pluie stagnante dans des dépressions naturelles.



## ZOOLOGICAL SURVEY OF INDIA, 1942-1945.

*By B. CHOPRA, D.Sc., F.N.I., Offg. Director, Zoological Survey of India,  
Kaiser Castle, Benares Cantt.*

### I. TEMPORARY REMOVAL OF HEADQUARTERS FROM CALCUTTA.

On the outbreak of war with Japan in December, 1941, the safety of the standard zoological collection of the Indian Empire, which is under the charge of the Zoological Survey of India and had been housed in the Indian Museum at Calcutta since the museum came into existence, became liable to serious damage or destruction by enemy action. As a first step all the type-specimens and class I exhibits of the Indian Museum were evacuated to the Forest Research Institute, Derha Dun. Though all normal air-raid precautions were adopted, it was however, felt that the safety of the collections that were still in Calcutta could not be ensured, unless they were totally removed to a less vulnerable area. On account of the very large quantities of Rectified Spirit, Naphthalene and other chemicals that are used for the preservation of the collections, books and other articles, there was not only the risk of serious damage to these highly inflammable collections, but it was apprehended that the safety of the whole Museum and even of men and property in the locality would be threatened. The Government of India, in consultation with the Bengal Government, therefore, decided that the entire collections and library etc. should be removed from Calcutta at as early a date as possible. As the Zoological Survey of India could not function without its collections and library, it became necessary to shift the entire headquarters of the Survey.

The finding of suitable accommodation, reasonably out of range of possible enemy action and sufficiently large to house the Survey, with its vast collections, library, laboratories and offices etc. was a difficult problem. Through the kindness of H. E. Supradipta Manyabara Commanding General Sir Kaiser Shamshe Jung Bahadur Rana, G. B. E., who generously placed his "Kaiser Castle" at Benares at the disposal of the Government free of rent, this difficulty was, however, ultimately overcome and the Government of India decided to remove the Zoological Survey of India to Benares. The evacuation to Benares was completed in a remarkably short time, with comparatively little damage to the collections, and Kaiser Castle, Benares Cantt. became the temporary headquarters of the Zoological Survey of India, with effect from the 11th May, 1942.

### II. DAMAGE TO THE COLLECTIONS AND LIBRARY ETC. IN THE VARUNA FLOOD OF 1943.

Kaiser Castle is a large building, or rather a number of semi-detached and detached buildings, in its own compound, situated on the bank of the Varuna River, well above its water-level. Some of the buildings are on somewhat higher ground than others and the plinth-level is not

the same even throughout the main building. The Varuna is a tributary of the Ganges, and, except during the rains, is a very small stream, with water only a few feet in depth. During the rains it swells up considerably and in many years of even normal rainfall, a small amount of its water enters the compound of the Kaiser Castle. At the time of the shifting of the Zoological Survey of India to Benares, the Varuna had never been in real flood within, living memory.

For the sake of safety, the spirit collections of the Survey are stored in a series of rooms in a separate block in the Kaiser Castle. These are arranged in open racks, six feet high, the racks being made firm to the walls by iron tie-rods. Two cellars in this block are also used for the storage of collections, but as the walls of these are lined with thick slabs of stone, it had not been found possible to fix tie-rods there. The dry collections of the Insect Section were housed in another separate building. In the main building were located, among others, the offices, laboratories, library, and most of the dry collections, excluding Insects.

In September, 1943, owing to very heavy and continuous rain for about three days all along its water-shed, there was a heavy flood in the Varuna, the water-level rising to an unprecedented height. By the evening of the 26th September water had entered the compound of the Kaiser Castle. The level continued rising, and on the afternoon of the 27th there was more than three feet of water above the plinth-level in most parts of the main building and even more in the other buildings. The flood began to recede on the morning of the 28th and by the 29th most of the rooms were more or less dry, though the underground cellars had still water in them up to the ceiling. The cellars had to be cleared later by means of trailer and centrifugal pumps.

As a result of the flood, large parts of the collections and library etc. were thus under water for more than two days and naturally suffered serious damage. Large numbers of bottles were washed off the shelves by the force of the current and were smashed. In the cellars, where no tie-rods had been fixed, the racks were lifted bodily and overturned. Some almirahs and boxes that had been stored on the verandahs were washed away. Labels came off the bottles in many cases even when the bottles remained standing on the shelves, and in most other cases became practically illegible by the deposition of silt. Parts of the building, including floors, were seriously damaged and caused further damage to the collections. Unfortunately the type-specimens had just been got back from Dehra Dun and were being unpacked and arranged in some sections, when the calamity occurred. Books in the library, Specimen Registers and other records also suffered serious damage on account of long immersion in water.

The work of salvaging the collections etc. was taken in hand immediately, and every effort was made to save as much as possible. Books, registers, records and dry collection were put out in the sun and thoroughly dried and first-aid rendered promptly, wherever possible. The collections were put in some sort of order as soon as the buildings had been repaired and with the help of temporary staff, specially sanctioned by the Government, the work of repair and reconstruction was started without delay, and is still going on. Thanks to the zeal, untiring efforts

and willing co-operation of the whole staff, who had to work under high pressure for months without a single holiday, a great deal has been saved. I take this opportunity of expressing my sincere thanks to the officers and staff of the Zoological Survey of India, but for whose selfless and sustained labour the damage to the national collections would have been far more serious than it is now.

Though the work of accurately assessing the extent of damage caused to the collections etc. in the Varuna flood of September, 1943, could not be started till the more urgent work of repair and reconstruction had been more or less completed, it is considered desirable to give to the scientific world at least a preliminary and rough idea of the damage suffered by the standard zoological collections of India. It is hoped that the work of correctly assessing the extent of damage, which on account of its nature and the size of collections involved, is bound to be long, slow and laborious, will be taken in hand shortly.

#### FISHES.

The collections of the Fish Section had been stored on 67 racks, 25 in one large room and 42 in a cellar under this room. In addition to the Cyclostoma, the Elasmobranchii, the Chondrostei and the Holostei, fishes of the sub-orders Ostariophysii and Malacopterygii of the order Teleostei and the entire unregistered collection of this Section had been kept in the cellar. In the upper room, where the rest of the collection had been stored, the racks, held fast and the damage was only slight. In the cellar, however, on account of the overturning of racks, large numbers of bottles were smashed and the specimens contained in them, including some types, remained in water for a number of days. Many of these specimens were lost and some, especially those of small size, disintegrated more or less completely on account of long immersion in water. Most of the type-specimens were fortunately saved, but a few of the deep-sea fishes of the sub-order Malacopterygii, which are generally brittle, were badly damaged or lost. Further, on account of the breaking of bottles, large numbers of specimens got mixed. In many cases number-tags made of metal had been fixed to individual specimens; the correct sorting of these presented little difficulty, but where no tags or other labels remained attached to the specimens, the work was extremely difficult and in many cases hopeless. Great care has been taken in this sorting out, and as far as possible, only specimens, about the authenticity of which there is no reasonable doubt, have been put back in the named collection. The bulk of the remaining material has been kept aside for the present and will be dealt with gradually.

A considerable part of the affected material consisted of unnamed specimens, and the damage suffered by these should not be regarded as serious. The loss and damage in the sub-orders Ostariophysii and Malacopterygii of the order Teleostei is however, of a serious nature. The following families of these sub-orders have been affected :—

Ostariophysii : Amblyceipitidae, Ariidae, Bagridae, Chacidae, Clariidae, Mochokidae, Pangasidae, Plotosidae, Schilbeidae, Siluridae, Sisoridae, Homalopteridae, Psilorhynchidae, Cyprinidae, Cobitidae and

Adiposiidæ; Malacopterygii: Alepocephalidæ, Stomiatidæ, Engraulidæ, Clupeidæ, Dorosomidæ, Dussumieriidæ, Chanidæ, Chirocentridæ, Elopidae, Megalopidae, Notopteridæ and Salmonidæ.

Two other orders of the Teleostomi, viz. Chondrostei, with its single family, the Acipenseridæ and Holostei, also with its single family, the Amiidæ, were also affected.

In the Elasmobranchii, the damage, though quite extensive, was not as serious as in the Teleostomi, on account of the fact that most of the Elasmobranchs are of a large size and could, therefore, better stand the effects of long immersion in water. The following families of the different orders and sub-orders have been damaged:—

Order Palagiostomi, sub-order Selachii: Scyllidæ, Carchariidæ, Sphyrinidæ, Spinacidæ and Rhinidæ; sub-order Batoidei: Pristidæ, Rhinobatidæ, Rajidæ, Trygonidæ, Torpedinidæ, Myliobatidæ and Rhinopteridæ; Order Holocephali: Chimeridæ.

In the Cyclostoma, the few specimens in the collection of the families Bodellostomatidæ, Myxinidæ and Petromyzontidæ were damaged.

It is impossible at this stage to give anything like an accurate assessment of the extent of damage suffered by the fish collections of the Zoological Survey of India. The orders and families mentioned above have been affected seriously, some others have suffered lightly, while many more have completely escaped damage. It is very roughly estimated that the total loss to these collections is in the neighbourhood of 20%.

#### REPTILIA AND AMPHIBIA.

The collections of this Section were stored in two rooms above ground and a small part in one of the cellars. In the smaller room, on account of the subsidence of floor, a rack, containing Amphibia, was overturned, but fortunately damage to the collection was only slight. In the other room in which Lizards and most of the Snakes were kept, the racks held fast and the damage there also was slight. The Chelonia and the larger Snakes were stored in the cellar and damage to these was heavy, on account of their long immersion in water. Fortunately very few types have been lost in this Section also.

In the order Testudinines, the families Emydidæ and Trionychidæ and in the order Squamata, sub-order Serpentes, the family Uropeltidæ have been seriously damaged. The Agamidæ, Scincidæ and Lacertidæ in the sub-order Sauria and the Colubridæ in the Serpentes have also been somewhat damaged. The Amphibians have practically escaped damage.

The total damage to the collections of the Reptilia and Amphibia Section is very roughly estimated at under 20%.

#### BIRDS AND MAMMALS.

More than half the collection of this Section was under water. Fortunately no specimens were actually lost, but nearly 27,000 of them (skins, bones, eggs and nests) got soaked and were more or less damaged. These are being attended to, but the work of repairing and restoring them is very slow and laborious. Many of the skins were very old, and it

is feared that damage to some of them can never be satisfactorily repaired. The Mammal types were not affected, except the type of dolphin *Tursiops pernix* (Blyth) which suffered damage, but it is now repaired, but nearly half the bird types were submerged; with proper care it has been possible to save practically all of them.

In the Mammals, the families Muridae, Ochotonidae and Leporidae of the order Rodentia, families Canidae, Mustelidae, Procyonidae and Ursidae of the Carnivora, and families Camelidae, Bovidae, Cervidae and Tragulidae of the order Ungulata have been seriously affected. The few specimens in the collections of the extra-Indian sub-order Hyracoidea of the Ungulata were also badly damaged.

In the Birds, the following families and subfamilies have suffered serious damage :—

Order Coraciiformes : Capitonidae, Coraciidae, Meropidae, Bucconidae, Cypselidae, Caprimulgidae, Podargidae, Trogonidae, Psittacidae, Strigidae, Asionidae and Cuculidae.

Order Accipitres : Falconidae, Gypsetinae and Pandionidae.

Order Gallinae : Phasianidae and Megapodidae.

Order Charadriiformes : Haematopodinae, Totaminae and Scolopacinae of the family Charadriidae.

Order Tubinares : Procellariidae.

Order Anseres : Anatidae.

It is roughly estimated that in about 15% of the Bird specimens and about 12% of the Mammals the damage is too serious to be satisfactorily repaired.

#### MOLLUSCA.

The spirit collection of this section has suffered very little damage. Though large parts of the collection were under water, very few specimens have been lost or damaged. The dry collection, which is a very large one, is stored in two rooms in the main building. In this also there was comparatively little actual loss of specimens, but heavy damage was caused by the mixing up of the specimen, on account of the disintegration of labels and the card-board boxes in which the shells were kept. Some amount of mixing up in this collection had already taken place, when the collections were evacuated from Calcutta. Every effort is being made to sort out the specimens correctly, but the work is proving extremely difficult. Most of the type-specimens are fortunately safe, but a few, that were very fragile, have been badly damaged, on account of continued immersion in water.

Dry specimens of about 40 families have been seriously damaged, and it is estimated that loss in the Section amounts to approximately 10% of the total collections.

#### CRUSTACEA.

Very little damage has been caused in the Crustacea Section. Some bottles were broken but most of the specimens contained in them have been saved and correctly sorted out. Practically all the types are safe. The total damage to the Crustacea collections will probably be in the neighbourhood of 5%.



## INSECTA.

The damage to the Insect collections has been unfortunately heavy. A considerable number of bottles in the spirit collections was broken, and a large number of specimens, including those of the Arachnida, were lost or got irretrievably mixed. The dry collection had been stored in a number of rooms in a separate block, and a part was kept in almirahs and racks on the verandah. Some almirahs and boxes stored on racks were washed away by the current and nearly 30% of the remaining dry collection was submerged in water. The damage to this collection has been serious not so much due to loss of specimens, but chiefly on account of the deposition of fine and sticky silt on a very large number of them. The work of removing this silt, even from hard-bodied insects, is bound to be very slow and extremely laborious, and will be almost impossible in the case of Diptera, Lepidoptera and other small and fragile insects. This work will take many years, and it is feared that a large number of specimens, in spite of every effort that is being made to restore them, will cease to be of much scientific value.

The dry types in the collection are fortunately all safe, but two boxes containing a large number of types in spirit, including a few of the Arachnida were washed away.

The following orders and families and special collections have suffered the greatest damage :—

Orthoptera : Phasmidae, Acridiidae and Gryllidae.

Rhynchotha, Heteroptera : Pentatomidae, Lygaeidae and Reduviidae ; Homoptera : Fulgoridae, Cercopidae, Jassidae, Aleyrodidae, Aphididae and Coccidae.

Neuroptera, Megaloptera : Sialidae and Raphidiidae ; Planipennia : Myrmeleonidae, Ascalaphidae, Mantispidae, Hemerobiidae, Chrysopidae and Nemopteridae.

Mecoptera : Panorpidae.

Trichoptera : Rhyacophilidae, Hydroptilidae, Philopotamidae, Stenopsychidae, Psychomyidae, Polycentropidae, Arctopsychidae, Hydropsychidae, Calamoceratidae, Odontoceridae, Molannidae, Leptoceridae, Sericostomatidae, Phryganeidae and Limnophilidae.

Lepidoptera, Rhopalocera : Nymphalidae, and Hesperiiidae ; Heterocera : Noctuidae, Bombycidae, Eupterotidae, Sphingidae, Lasiocampidae, Lymantriidae, Hypsidae, Uraniidae, Epiplemidae, Notodontidae, Cymatophoridae, Sessiidae, Tinaegeriidae, Zygaenidae, Psychidae, Hepialidae, Callidulidae, Drepanulidae, Cossidae and Saturniidae.

Green's Collection of Butterflies and Dudgeon's collection of moths have also suffered considerable damage.

Coleoptera. Adephaga : Carabidae, Dytiscidae, Gyrinidae, Paussidae, and Rhysodidae ; Polyphaga : Staphylinidae, Endomychidae, Dermestidae, Byrrhidae, Nosodendridae, Georyssidae,

Parnidae, Hydrophilidae, Heteroceridae, Dascillidae, Helodidae, Malacodermidae, Buprestidae, Elateridae, Xylophilidae, Anthicidae, Tricentenotomidae, Bruchidae, Chrysomelidae, Cerambycidae, Lamiidae, Brentidae, Curculionidae, Passalidae and Scarabaeidae.

Hymenoptera, Apocrita : Ichneumonidae, Formicidae, Vespidae, Mutillidae, Chrysididae, and Colletidae.

Diptera, Nematocera : Tipulidae, and Mycetophilidae ; Brachycera : Coenomyiidae, Tabanidae, Cyrtidae, Nemestrinidae, Therevidae, Bombyliidae and Asilidae ; Cyclorrhapha : Sapromyzidae, Ochthophilidae, Agromyzidae, Celyphidae, Diopsidae, Borboridae, Heteroneuridae, Sciomyzidae, Helomyzidae, Cordyluridae, Oestridae, Tachinidae, Calliphoridae, Hippoboscidae, Nycteribidae and Streblidae.

Aphaniptera : Pulicidae.

In many of the families mentioned above, specimens of only one or two subfamilies have been damaged, while those of the remaining subfamilies are safe. Families that have been lightly affected and the very large number of those that have not suffered at all are not mentioned. It is very difficult to estimate at this stage even the approximate extent of damage to the collections of the Insect Section, but it seems likely that the total damage will turn out to be in the neighbourhood of 20%.

#### OTHER INVERTEBRATES.

The spirit collection of this Section has not been seriously affected, but the dry collection has suffered damage.

Porifera : The spirit collection is nearly intact, but approximately 15% of the dry specimens have been damaged on account of long soaking in water.

Coelentrata : The dry collections of the Madreporaria and the Gorgonacea have suffered most. In the former, paper-tags and plaster numbers attached to many specimens have been completely destroyed ; the sorting out of these specimens is proving extremely difficult, and it is possible that about 40% of these corals may have to be written off. The Gorgonacea had been left packed in boxes and, on opening, most of the specimens were found broken in bits, with their paper labels completely destroyed. The damage to the Hydrozoa, Aleyonaria and other groups is negligible.

Platyhelminths, Nematelminths and Polyzoa, etc. have suffered practically no damage.

Echinodermata : A few dry specimens have been damaged or lost.

Annulata : In the Polychaeta about a hundred bottles were broken and some specimens, including two types of the family Nereidae, were lost. In the Oligochaeta, Hirudinea and other group there was very little damage.

The collection of slides, including some type-slides, has also been damaged. The slides were kept in cabinets in the main building, and, on account of long immersion in water, some of these were damaged

and the labels of most of them came off. These are being attended to, and it is hoped that a large number of them will be correctly sorted out.

The total damage to this Section is roughly estimated at about 10%.

#### SPECIMEN REGISTERS.

Out of the 70 Registers in which records of specimens in the collection are kept, 43 were immersed in water. Many of the Registers are very old and on account of the age and brittleness of their paper, have suffered considerable damage in the flood. Fortunately the entries in the Registers are still legible. All the damaged and old Registers are being copied and it is hoped that this work will be satisfactorily completed before long.

#### LIBRARY.

About one-third of the books in the Library, approximately 10,000 in number, were wholly or partially under water and, therefore, suffered damage. Most of these damaged books have been repaired and rebound, and fortunately total loss is only slight, as not more than 200 books only have to be written off. In another 500 or so, some pages have been torn or lost. In addition, in quite a large number, printed wholly or partially on art paper, pages, specially those containing illustrations, got stuck; these were separated with as much care as possible, but even then considerable damage has been caused. The stock of Departmental publications and unbound reprints and other papers also suffered some damage.

#### MICROSCOPES, CAMERAS AND OTHER INSTRUMENTS.

All these were submerged in water, but fortunately little permanent damage has been caused to these.

I have given in the foregoing paragraphs a brief account of the nature of damage suffered by the collections etc. of the Zoological Survey of India in the Varuna flood and have very roughly indicated the extent of this damage, as known at present. The damage to the National collections has been serious, but fortunately the collections are still substantially intact. Every effort is being made to repair and make good the damage and loss as far as possible. I take this opportunity of appealing to all naturalists, zoologists and other scientists in India and abroad to help us in adding to these collections and thus in not only making good the loss suffered, but in making them better and more representative of the Indian fauna than they have been ever before. Though all presentations and exchanges will be gratefully received, it will be specially appreciated if specimens of the orders and families that have been seriously damaged are sent to us.

### III. THE PUBLICATIONS OF THE ZOOLOGICAL SURVEY OF INDIA.

The publication of the *Records of the Indian Museum*, *Memoirs of the Indian Museum* and *Report of the Zoological Survey of India* had unfortunately to be suspended in 1942, in view of the urgent need for

economy in the use of paper. The last issues of these publications, prior to suspension, were: *Records*, XLIV, part III, *Memoirs*, XIII, No. 4 and *Report*, for the years 1938-41.

The publication of the *Records of the Indian Museum* is now being resumed. The present issue will be the concluding part of volume XLIV, and an index to the volume will be issued as soon as possible. The next volume, XLV, will commence in 1947 and attempts will be made to complete it within the year. From 1948, it is hoped to bring out a yearly volume, as previously.

#### IV. ANTHROPOLOGY.

The Anthropology Section of the Zoological Survey of India has been separated from the Survey with effect from the 1st December, 1945, with a view to converting it into a separate Department or Survey. Anthropological work, that was formerly being done in the Zoological Survey of India is now under the care of the Director, Anthropological Survey of India, with his temporary headquarters at 64, Cantonment Benares. The Ethnological and Anthropological collections are also now housed at the same address.



DESCRIPTION OF A NEW FILARIID WORM, *SQUAMOFILARIA*  
*CHOPRAI*, SP. NOV. (NEMATODA) FROM THE LUNG OF A  
SEA-TERN, FROM ADDU ATTOL, MALDIVE ISLANDS.

By B. S. CHAUHAN, M. Sc., Ph. D., F.Z.S., Assistant Superintendent,  
Zoological Survey of India, Benares Cantt.

A single specimen of a Filariid parasite was obtained by Major S. L. Kalra, in September 1944, from the lung of a sea-tern, from Addu Attol, Maldive Islands. It was kindly passed on to this department for study by Major Dr. M. L. Roonwal. Unfortunately, the specimen is not in a very good state of preservation; nevertheless, a study of the worm reveals that it represents a new species of the nematode genus *Squamofilaria*.

Super Family FILARIOIDEA (Weinland, 1858) Stiles, 1907.

Family FILARIIDAE (Cobbold, 1864) Claus, 1885.

Sub-Family APROCTINAE Yorke and Maplestone, 1926.

Genus *Squamofilaria* Schmerling, 1925.

1926 *Coronofilaria*, Yorke and Maplestone, The Nematode Parasites of Vertebrates, London., p. 409.

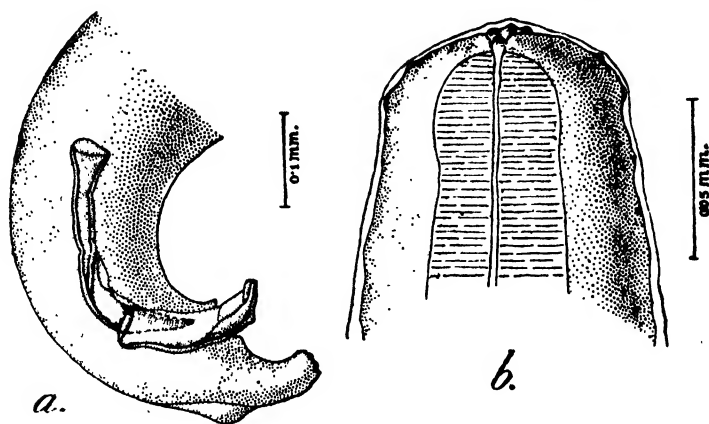
*Squamofilaria choprai*<sup>1</sup>, sp. nov.

*Specific Diagnosis*: *Squamofilaria*—with generic characters.

Body filiform, tapering at both extremities. Length about 15 mm., maximum width of body, in mid-region, about 0.3 mm. Head (Fig. 1*b*) round, tapering and broad; mouth surrounded by a cuticular collar, festooned to form a crown-like structure, with six small 'lips'; head papillae submedian, two pairs, rather inconspicuous; lateral papillae probably two. Cuticle very finely striated transversely, with occasional papilla-like bosses, varying much in their development, more conspicuous in posterior region, specially on ventral side. Mouth cavity small; oesophagus simple. Posterior extremity (Fig. 2*a*) coiled spirally; tail of male short and rounded; caudal end flat, studded with spine-like round, cuticular papillae. Male genital opening situated at a distance of about 0.09 mm. from posterior end. A large and conspicuous median papilla situated just in front of cloacal opening; a similar, but less conspicuous, median post anal papilla visible. Spicules two, subequal, thick and trough like. Anterior spicule much larger than posterior, about 0.26 mm. in length, bent like the letter L, probably with a ventral groove, its posterior extremity pointed. Posterior spicule short and stout with its posterior end bifid and spatulate, measuring

<sup>1</sup> Named after Dr. B. N. Chopra, Director, Zoological Survey of India.

0.16 mm., caudal alae absent. Lateral rows of small and oval, pigmented corpuscles, characteristic of the other two species of the genus, absent.



TEXT FIG. 1.—*Squamofilaria choprai*, sp. nov.  
a, Posterior end; b, Anterior end of the male.

The genus *Squamofilaria* was created by Schmerling, 1925 for *Filaria coronata* Rudolphi, 1809. Yorke and Maplestone (1926) created another genus *Coronofilaria* with *C. pillersi* as the type and *C. coronata* (Ru l., 1809) as the other species of the genus. They also included, with some doubt, the species *Eucamptus obtusus* Dujardin, 1845, from *Caprimulgus europaeus*, in their genus, on the ground that the generic name *Eucamptus* is preoccupied. Thus the genus *Coronofilaria* of Yorke and Maplestone falls in the synonymy of the genus *Squamofilaria*. I am also not inclined to include the species *E. obtusus* in the genus. The genus *Squamofilaria*, therefore, now contains only two previously described species: *S. coronata* (Rud., 1809) from *Coracias garrula*, type species and *S. pillersi* (Yorke & Maplestone, 1926) from the blue warbler fly-catchers. The new species described above differs from the type in the nature of the mouth collar, the position of the submedian head papillae and the size and nature of the spicules. The nature of the posterior extremity is also different in the new species. *S. choprai* differs from *S. pillersi* in the nature of the mouth cavity, the size and nature of the spicules and the absence of two lateral rows of small and oval pigmented corpuscles.

Type-specimen. -W 3640/1, Zoological Survey of India.

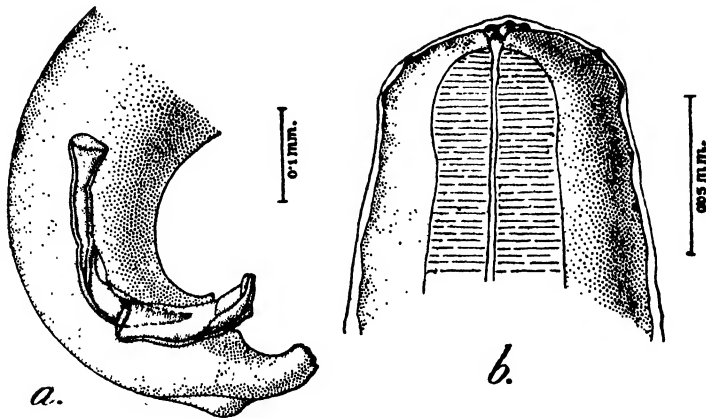
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- Wehr, Everett E., 1935.—A revised classification of the Nematode Superfamily Filarioidea. *Proc. Helminth. Soc. Wash.* II, pp. 86, 87.
- Yorke, W. & Maplestone, P. A., 1926.—*The Nematode Parasites of Vertebrates*, London, pp. 409, 410.



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Dujardin, F., 1845.—Histoire naturelle des Helminthes ou vers intestinaux, Paris, xvi+654+15 pp.

- Rudolphi, C. A., 1808.—*Entozoorum sive vernium intestinatium historia naturalis* II, pp. 457. Amstelædami.
- Wehr, Everett E., 1935.—A revised classification of the Nematode Superfamily Filarioidea. *Proc. Helminth. Soc. Wash.* II, pp. 86, 87.
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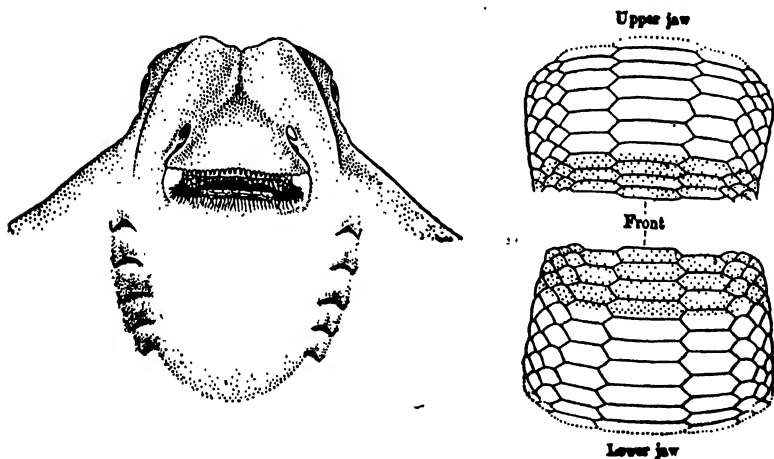
## A NEW SPECIES OF RHINOPTERID FISH FROM SOUTH INDIA.

By K. S. MISRA, D. Sc., F.Z.S., Assistant Zoologist, Zoological Survey of India, Benares Cantt.

(Plate I.)

### **Rhinoptera sewelli**, sp. nov.

In the new species of *Rhinoptera*, described in this note, the length of disk is contained from 1.55 to 1.69 times in its depth and from 1.42 to 1.44 times in its tail. The head is notched in front of the fontanel and between the cephalic fins. The head is contained from 3.98 to 4.12 times in the length of the disk. The diameter of the eye is contained from 5.50 to 6.15 times in the head; from 5.53 to 5.76 times in interorbital width and from 2.58 to 2.92 times in the length of the snout. One



TEXT-FIG. 1.—*Rhinoptera sewelli*, sp. nov.,

Ventral view of head;  $\times 1/3$ ; Dentition in upper and lower jaws;  $\times 1$ .

edge of the upper lip is fringed, and that of the lower lip is papillated. The teeth are in nine rows on both the jaws, those in the median row 3.6 times as wide as long, those in the next row 2.3 times as wide as long and those in the outer three rows on each side as wide as long. Median rows are narrower on the lower jaw. The gill openings are moderate and equidistant. The last gill opening is the smallest. The spiracles are about double the size of the eye and are situated closely posterior to the eye. The tail is whip-like with a dorsal fin and two small serrated caudal spines above its basal portion. The anterior and posterior caudal spines are very closely apposed together. The anterior and posterior caudal spines are contained from 9.37 to 13.6 and from 2.42 to 3.2 times in the interorbital width respectively.

There is no anal fin. Both the front and the hind edges of the pectoral fins are concave.

The skin is smooth.

In specimens preserved in formalin the dorsal surface and the tail are blackish grey and the ventral surface is pinkish white.

*Type-locality*.—West Hill, off the Calicut coast, Arabian Sea, (Collected by Mr. K. C. Chacko, Govt. Fish curing Yard, West Hill, on 24-11-44.)

*Holotype*.—F79/2, Zoological Survey of India.

*Remarks*.—*Rhinoptera sewelli*, sp. nov. is distinguished from its congeners mainly by the following character:—

Teeth in nine rows in both the jaws (*versus* teeth in seven rows in *R. quadriloba* Lesueur, *R. lalandii* M. H., *R. javanica* M. H., *R. steindachneri* Evermann & Jenkins and *R. neglecta* Ogilby, teeth in nine rows in upper jaw and seven in the lower in *R. marginata* G. Saint-Hilaire, *R. adspersa* M. H., *R. jussieu* C., *R. jayakari* Blgr. and *R. peli* Blkr., teeth in 15 rows in upper and 19 in the lower in *R. polyodon* Gthr. and teeth in 14 rows in the lower jaw in *R. encenadae* Smith).

I have much pleasure in naming this new species in honour of Lt. Col. R. B. Seymour Sewell, C.I.E., F.R.S., I.M.S. (Retd.), formerly Director, Zoological Survey of India.

#### *Measurements in millimetres.*

Total length . . . . .	619.0	684.0	752.0
Length of disk . . . . .	272.0	291.0	330.0
Depth of disk . . . . .	437.0	452.0	560.0
Length of head . . . . .	66.0	73.0	80.0
Diameter of eye . . . . .	12.0	12.0	13.0
Interorbital width . . . . .	64.0	68.0	75.0
Length of snout . . . . .	31.0	34.0	38.0
Width of mouth . . . . .	48.0	50.0	54.0
Preoral length . . . . .	42.0	45.0	47.0
Internarial length . . . . .	35.0	36.0	40.0
Length of dorsal fin . . . . .	28.0	29.0	33.0
Length of base of dorsal fin . . . . .	24.0	28.0	29.0
Length of anterior caudal spine . . . . .	5.0	5.0	8.0
Length of posterior caudal spine . . . . .	20.0	28.0	damaged
Length of tail . . . . .	387.0	425.0	473.0
Sex . . . . .	♀	♂	♂

#### ACKNOWLEDGMENTS.

I am grateful to Dr. B. N. Chopra, D. Sc., F.N.I., Director, Zoological Survey of India for kindly going through the manuscript and for his helpful suggestions and to Mr. Devi Das Menon, B. Sc., (Hons.), Research Assistant, Marine Biological Station, West Hill, S. Malabar for supplying some specimens of this new species.



EXPLANATION OF PLATE I.

*Rhinoptera sewelli*, sp. nov., Dorsal view :  $\times 7/16$ .







## ACANTHOCEPHALA FROM INDIA.

### III. ON A NEW GENUS OF ACANTHOCEPHALAN PARASITE OF THE FAMILY QUADRIGYRIDAE, FROM A CALCUTTA FISH, *MYSTUS CAVASIUS* (HAM.).

By M. N. DATTA, M.Sc., Assistant Zoo'ogist, Zoological Survey of India, Benares Cantt.

The parasites described in the present note were collected by Dr. T. N. Podder of the Carmichael Medical College, Calcutta from the intestines of small siluroid fishes, *Mystus cavasius* (Ham.) found in the Calcutta fish markets. The worms are small and on examination revealed characters of the family Quadrigyridae. They do not, however, tally completely with the descriptions of any of the existing genera, and a new genus *Raosentis*, with *Raosentis podderi* as its genotype, is, therefore, proposed to accommodate them.

#### *Raosentis*, gen. nov.

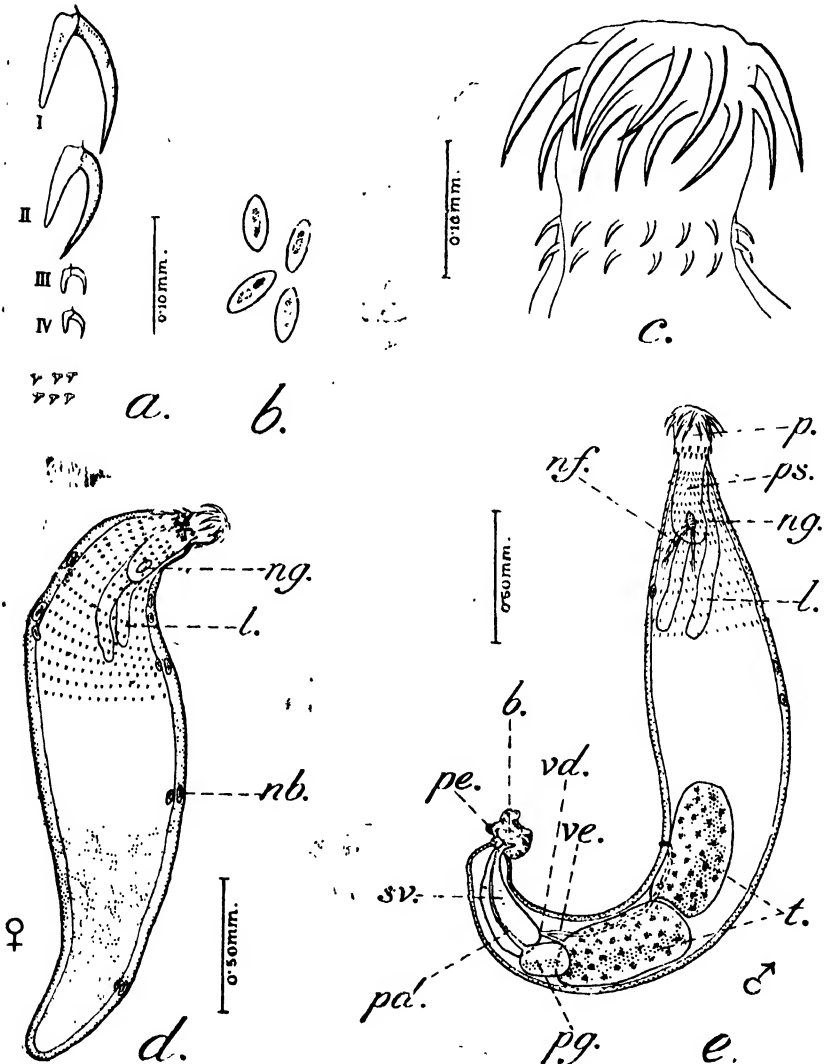
*Generic diagnosis*.—With the characters of the family Quadrigyridae ; worms of small size parasitic as adult in the alimentary tracts of fishes. Proboscis slightly elongated or globular with 4 circles of hooks, 6 in the first two circles very long and stout and 7 in the next two circles small and slender. Some space devoid of spines, present between the second and third circles of proboscis hooks. Anterior region of the body provided with 17 rows of close-set rose-thorn-like spines. Proboscis-sheath composed of a single layer of muscles. Central nerve ganglion situated near the posterior end of proboscis-sheath. Subcuticular nuclei in pairs, 4 or 5 pairs on the dorsal and 1 or 2 on the ventral side.

#### *Raosentis podderi*, gen. et sp. nov.

The worms are of small size, spindle-shaped and whitish in colour. The proboscis is globular and sometimes slightly elongated, 0.14—0.25 × 0.12—0.18 mm. in size. The hooks on the proboscis are in four circles, the anterior two circles have 6 hooks in each and the posterior two circles have 7 in each. Hooks of the anterior two circles are stouter and longer than those of the third and fourth circles. There is a prominent gap of spineless space between the second and third circles of proboscis hooks. Measurements of proboscis hooks are : first circle 0.085—0.115 mm ; second 0.070—0.095 mm ; third 0.025—0.035 mm ; fourth 0.025—0.030 mm. The anterior end of the body is provided with 16 or 17 circles of 32-34 rose-thorn-like hooks each ; the basal plates of these hooks are embedded in the body-wall (Text-fig. 1, *a* and *c*).

The subcuticular nuclei are small and in pairs, four or five pairs on the dorsal and one or two pairs on the ventral side of the body-wall. The proboscis-sheath is a thin single-layered muscular sack. The retractor and protractor muscles controlling the movements of the

proboscis are thin but firmly attached to the proboscis-sheath. The central nerve ganglion is a small, elongated structure situated at the base of the proboscis-sheath and the nerve retinaculi coming out from the ganglion pass out to the body-wall through the posterior side of the proboscis-sheath. The two lemnisci are slightly longer than the sheath, 0.28—0.60×0.05—0.07 mm. (Text-fig. 1, d.).



TEXT-FIG. 1.—*Baosentis podderi*, gen. et sp. nov.

a. Hooks of the proboscis and body magnified; b. Eggs; c. Proboscis showing arrangement of hooks; d. Female showing arrangement of body hooks and lacunar system; e. Male showing genitalia, proboscis sheath, lemnisci, nerve ganglion and nerve fibres.

b. bursa; l. lemnisci; nb. body nucleus; nf. nerve fibres; ng. central nerve ganglion; p. proboscis; pd. prostatic duct; pe. penis; ps. proboscis-sheath; sv. seminal vesicle; l. testes; vd. vas-deferens; ve. vas-efferens.

Lacunar system is clearly seen. There are two longitudinal canals running along the dorsal and ventral sides of the body and lateral canals coming out from these longitudinal canals run round the body at regular intervals, giving it a segmented appearance. Branches from the lateral canals, called canaliculi, are also present. In the females the lacunar system is very prominent in the posterior portion (Text-fig. 1, *d*).

The genitalia are situated in the posterior half of the worms. The male genitalia (Text-fig. 1, *e*) consist of a pair of ovoid testes arranged tandemwise close to each other. The two vasa-efferentia leading from the two testes join together below the prostatic gland to form the vas-deferens before opening into the seminal vesicle. The prostatic gland is a round mass just behind the posterior testis and contains about 8-10 nuclei. A duct from the prostatic gland, the prostatic duct, opens in the seminal vesicle near the posterior end and the seminal vesicle opens into the thick muscular and conical penis, which hangs at the top of the eversible bursa. The seminal vesicle is a thin-walled muscular sac which, in the breeding season, is full of sperms. In some cases a couple of glandular structures are seen on top of the bursa, just on the sides of the seminal vesicle, and their function seems to be to lubricate the copulatory organs at the time of mating. The female genitalia consist of a uterine-bell, which hangs in the body cavity by means of some muscle fibres attached at the anterior extremity to the base of the proboscis-sheath. The uterine-bell leads into a long tubular uterus; the uterus leads into the narrow vagina which opens at the posterior end of the worm by means of a small opening, the vulva. The vagina is guarded by two bands of muscles to control the extrusion of the mature ova in a single file. A pair of small glands, termed as vaginal glands, are seen on both sides of the vulva. At the base of the uterine-bell there are a few cells, known as guard cells, which serve to sort out the mature from immature ova; the mature ones are allowed to pass into the uterus and the immature ones are thrown back into the body cavity for further development. Eggs are elliptical, measuring  $0.050 \times 0.020$  mm. (Text-fig. 1, *b*.)

*Measurements.*—Males,  $0.67-2.37 \times 0.27-0.53$  mm.; females,  $1.31-2.53 \times 0.42-0.64$  mm.; proboscis,  $0.14-0.25 \times 0.11-0.18$  mm.; proboscis hooks, (i)  $0.085-0.115$  mm.; (ii)  $0.070-0.095$  mm.; (iii)  $0.025-0.035$  mm.; (iv)  $0.025-0.030$  mm.; proboscis-sheath,  $0.16-0.37 \times 0.05-0.14$  mm., lemnisci,  $0.28-0.60 \times 0.05-0.07$  mm.; testis anterior,  $0.506 \times 0.242$  mm., posterior,  $0.460 \times 0.184$  mm.; prostatic gland,  $0.184$  mm.; seminal vesicle,  $0.368$  mm.; bursa,  $0.138$  mm.

*Host.*—*Mystus cavasius* (Ham.).

*Location.*—Intestine.

*Locality.*—Calcutta (Market).

*Types.*—Male and female (W3679/1) deposited in the collections of the Zoological Survey of India.

*Discussion.*—It is evident from the accompanying table that the new genus agrees in some points with the existing genera of the family Quadri-gyridae, but it differs considerably in the shape and size of the body, the size of the proboscis, circles of hooks on the proboscis, the position and number of hooks in each circle, the comparative size of the lemnisci

*Characters of genera of the family Quadrigyridae.*

Names of genus.	Dimensions of body.	Measurements of proboscis.	Proboscis hooks.		Measurements of prob. hooks.	Body spines.	Lemmings.	Body nuclei.	Host.
			No. of circles.	No. in each circle.					
1. <i>Quadrigyris</i> Van-Cleave 1920	$\sigma$ 8.0—10.0 × 0.6 $\Omega$ 10.0—20.0 × 9.0—1.25	0.024	4	5	i. 0.096—0.106 ii. 0.076—0.100 iii. 0.053—0.059 iv. 0.041—0.047	4 rows at anterior end	longer than prob.-sheath.	ant. elliptical in sagittal plane, rest large branched, laterally placed.	fishes.
2. <i>Palisensis</i> Van-Cleave 1928	6.0—10.0 × 0.3	0.2 in diameter.	4	6	i. 80—119 $\mu$ ii. 83—100 $\mu$ iii. 53—65 $\mu$ iv. 35—41 $\mu$	collar of 6-9 rows of spines at ant. extremity followed by 20—40 widely separated rows.	long, cylindrical.		fishes.
3. <i>Acanthosentis</i> Verma & Datta 1929.	$\sigma$ 1.0—1.25 × 0.2 $\Omega$ 0.25 $\sigma$ 2.0—3.0 × 0.75 —1.0	0.04—0.25 × 0.04—0.16	3	6	i. 72.0 × 16.6 ii. 52.0 × 13.2 iii. 48.0 × 12.0	20—31 rings on anterior two-fifth of body.	longer than prob.-sheath. 0.04—0.34 × 0.03—0.10	few branched and oval nuclei.	fishes.
4. <i>Neosentis</i> Van-Cleave 1928	$\sigma$ 10.0 × 0.85 $\Omega$ 17.0 × 1.70		4	8	i. 53—59 $\mu$ ii. 33—39 $\mu$ iii. 35—41 $\mu$ iv. 30—33 $\mu$	5-6 rings at ant. extremity a gap and then 6-8 circles and scattered hooks.	long, cylindrical and in male reaching up to ant. testis.		fishes.
5. <i>Heterosentis</i> Van-Cleave 1931	$\sigma$ 4.94 × 0.59 $\Omega$ 4.75—5.85 × 0.4—0.79		10	4 or 5					fishes.
6. <i>Raoosentis</i> , gen. nov.	$\sigma$ 0.67—2.37 × 0.27—0.53 $\Omega$ 1.31—2.53 × 0.42—0.64	0.14—0.25 × 0.12—0.18	4	1st and 2nd rows 6 each; 3rd and 4th rows 7 each.	i. 0.085—0.115 ii. 0.070—0.095 iii. 0.025—0.035 iv. 0.025—0.030	17 rings of close-set, rose-thorn-shaped spines.	a little longer than prob.-sheath.	small, in pairs, 4-5 dorsal, 1-2 ventral.	fishes.

Measurements are in millimetres, except where indicated.

and the proboscis-sheath and the shape and disposition of the body spines. From Van Cleave's description of the genera *Quadrigyrus*<sup>1</sup> *Pallisentis*,<sup>2</sup> *Neosentis*<sup>3</sup> and *Heterosentis*<sup>4</sup> it is evident that the specimens of these genera are much longer than those of the new genus. The number of circles of proboscis hooks is the same, but the number of hooks in each circle in the new genus differs from them and in Verma & Datta's *Acanthosentis*.<sup>5</sup> In the disposition of the body spines also there are considerable variations and the new genus is easily differentiated. In *Quadrigyrus* there are only four rows at the anterior end, in *Pallisentis* there is a collar of 6-9 rows of spines at the anterior extremity followed by 20-40 widely separated rows, in *Acanthosentis* there are 20-31 rings on the anterior two-fifth of the body and in *Neosentis* there are 5-6 rings at the anterior extremity, then a spineless gap, followed by 6-8 circles and scattered spines: in the new genus there are 17 rings of close-set rose-thorn-like small spines. In the size of the lemnisci and their comparative size with the proboscis-sheath, *Raosentis* differs from the existing genera. The body nuclei also differ in being peculiarly placed in pairs. On the basis of the characters enumerated above, the new genus *Raosentis* can be easily distinguished from all the existing genera of the family Quadrigyridae.

I have great pleasure in associating the generic name with that of Dr. H. S. Rao, D.Sc., Deputy Fisheries Development Adviser, Government of India. The specific name is associated with the name of Dr. T. N. Podder, M.Sc., M.B. of Carmichael Medical College, Calcutta who very kindly gave me the specimens for study. My thanks are due to Dr. B. N. Chopra, D.Sc., Director, Zoological Survey of India, for kindly giving me help and facilities for my work here. I must also record my thanks to Mr. R. C. Bagchi, our Artist who finished the figures for this paper.

<sup>1</sup> Van Cleave, H. J., Two new genera and species of Acanthocephalous worms from Venezuelan fishes. *Proc. U. S. Nat. Mus.* LVIII, pp. 455-466 (1920).

<sup>2</sup> Van Cleave, H. J., Acanthocephala from China. I. New species and new genera from Chinese fishes. *Parasitology* XX, pp. 1-9 (1928).

<sup>3</sup> Van Cleave, H. J., *Ibid.*

<sup>4</sup> Van Cleave, H. J., *Heterosentis*, a new genus of Acanthocephala. *Zoolog. Anz.* XCIII, pp. 144-146 (1931).

<sup>5</sup> Verma, S. C. and Datta, M. N., Acanthocephala from Northern India. I.—A new genus *Acanthosentis* from a Calcutta fish. *Ann. Trop. Med. Parasit.* Liverpool XXIII, pp. 483-494 (1929).



## STUDIES IN INTRASPECIFIC VARIATION.

### I. ON THE EXISTENCE OF TWO COLOUR-TYPES IN THE ADULTS AND HOPPERS OF THE *SOLITARIA* PHASE IN THE DESERT LOCUST, *SCHISTOCERCA GREGARIA* (FORSKÅL). [ORTHOPETRA, ACRIDIDAE.]<sup>1</sup>

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#### FOREWORD.

The value of the study of intraspecific variations for the understanding of various problems of evolutionary biology needs no emphasis. Of such variations there exist numerous categories ranging from morphologically distinct geographical subspecies (many of which were formerly accorded full specific rank) to smoothly graduated clines and mere physiological races (*vide* Huxley, 1944, for summary). Recent experience has shown that every species and its lower systematic units must be investigated intensively on its individual merits, and deductions or generalizations based on even closely allied species may often prove to be misleading and erroneous.

The Desert Locust, *Schistocerca gregaria* (Forskål), has proved to be an excellent material for the study of intraspecific variations. Apart from the ordinary allometric variations, there are, in this species, firstly, the phase variations, *viz.*, the existence of *gregaria* and *solitaria* phases (Uvarov, 1923, 1928; and others). Secondly, there are non-phasic variations of which the first instance was provided by me (Roonwal, 1936). This variation referred to the existence of two different kinds of individuals (6- and 7-eye-striped) in the *solitaria* phase. These observations were later confirmed and extended (Roonwal, 1937, 1938, 1941, 1945-1946; Rao, 1937, 1938; Rao and Gupta 1939; Volkonsky, 1938, 1938a; and Mukerji and Batra, 1938). As a result, we now know that in *solitaria* populations mostly 6- and 7-striped (rarely 8-striped) individuals occur, while in *gregaria* populations (swarms) only 6-striped individuals are found; occasionally, 5-striped individuals turn up in laboratory breedings.

In the present series of papers I propose to describe, in the Desert Locust, intraspecific variations particularly other than those referred to above, and also to discuss the biological significance of the variations especially concerning the eye-stripes.

#### INTRODUCTION.

Colour differences, in both adults and hoppers, between the two phases, *solitaria* and *gregaria*, are now well-known in the Desert Locust, *Schistocerca gregaria* (Forskål) (*vide* Uvarov, 1928). But I do not think it

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<sup>1</sup> A preliminary report appeared in *Nature* CLV, p. 792 (1945).



is yet known that in the *solitaria* phase we can distinguish two distinct colour-types in both adults and hoppers. In the present paper I shall describe these colour-types and discuss their probable significance.

#### ADULTS.

Künckel d'Herculais (1892) first showed that swarming adults of the Desert Locust are at first pink, but later become yellow with maturity. Johnston (1926) showed that this colour change is characteristic of *gregaria* individuals only; the *solitaria* adults are greenish when young and become greyish later, but do not change colour with maturity; this was confirmed by Ballard, Mistikawi and El Zoheiry (1932).

I have, however, noticed that after a few days of the initial greenish tinge, two colour-types can be distinguished among the *solitaria* adults. Firstly, the type comprising those individuals which are suffused with a blue-grey tinge all over the body; these constitute the majority. Secondly, the type comprising those individuals which are pale buff or fawn in overtone, without any blue-grey; these occur in very small numbers.

For brevity, the two types of *solitaria* may be known as *blue* and *fawn*. The two types are clear in specimens freshly caught in the field. With preservation, however, the colours change, and in museum specimens it is no longer possible to distinguish the two types. In 367 *solitaria* individuals from southern Baluchistan (November, 1935 to September, 1936), 335 (161♂♂, 174♀♀) or 91 per cent. were blue and 32 (19♂♂, 13♀♀) or 9 per cent. fawn.

From a careful analysis, I was unable to correlate the two types with age, sex, season, E/F ratio and the number of eye-stripes (i.e., the proportion of 6- and 7- eye-striped individuals, *vide* Roonwal, 1936, 1945, 1945a) and phase.

Vayssiére and Lepesme (1939), from breedings in the Laboratoire central de Biologie acridienne, Paris, figure two adults of the Desert Locust (their Pl. III, figs. 3 and 5) which give a good idea of the coloration of the *blue* and *fawn* types as understood by me, though Vayssiére and Lepesme themselves interpret them quite differently. On p. 61 they describe fig. 3 (blue) as "Adulte type normal de l'élevage, 2 mois après la mue imaginale"; and fig. 5 (fawn) as "Adulte obtenu en élevage isolé". No further history is given, but the meaning of "type normal" can be partly inferred by reference to p. 44 where they state: "Les individus normaux de l'élevage sont toujours du type *transiens*, parfois plus voisins du type *gregaria*, parfois plus près du type *solitaria*". And further: "Dans les conditions de notre élevage, les stades larvaires sont très voisins du type grégaire au point de vue de la pigmentation". Thus, since under the breeding conditions the hoppers were very close to the *gregaria* type in pigmentation, we may infer that these authors implied that the "type normal" adult illustrated in fig. 3 was in phase *gregaria* or at least *transiens*, in contrast to that in fig. 5 which is clearly stated to have been obtained in isolated breeding and so indicating that it was typical *solitaria*. Vayssiére and Lepesme thus imply a phase significance to these figures. From considerable field and laboratory experience regarding the Desert Locust, I can say that in general facies fig. 3, like fig. 5,

appears to be that of a *solitaria* phase individual. As regards pigmentation, there can be no doubt that fig. 3 is *not* that of a *gregaria* individual for, in that phase the immature adults are pinkish and the mature ones yellowish; they are *never* bluish. The term *transiens* is very fluid. It is fairly useful in the study of biometrical ratios of adults and the pigmentation of hoppers. But as regards adult coloration it does not convey any clear impression, and distinction between *solitaria* and *transiens* colours is not at all possible.

#### HOPPERS.

Phase *solitaria* hoppers of the Desert Locust are generally known to have a bright green colour (Johnston, 1926; Ballard, Mistikawi and El Zoheiry, 1932; Faure, 1932; Husain and Mathur, 1936; and Kennedy, 1939). The majority are undoubtedly so.

Besides green hoppers, however, there occasionally turn up in laboratory breedings (briefly reported by Roonwal, 1937, p. 149; *vide infra*), as well as in field collections, a few fawn-coloured hoppers *without any green*. These fawn hoppers are undoubtedly *solitaria*, as judged from breeding records (isolated breeding) and from field observations. In the field, for instance, a fawn hopper may be found among a batch of 10 or 12 green ones in a desert bush. The fawn colour becomes well-marked in the older hopper stages only, especially the fourth and fifth. Exact figures were not recorded, but my impression is that the frequency of appearance of the fawn hoppers does not exceed 10 per cent. of the total *solitaria* population, and is perhaps less. It must be emphasized that such hoppers are by no means abnormalities. Their occurrence is regular enough, and they are in no respect less healthy than green individuals. The appearance of fawn hoppers is not connected with food and such other external factors for, they occur simultaneously with green hoppers bred under identical conditions in the laboratory and also under identical conditions in the field, *e.g.*, on the same bush.

To a certain extent, according to Rao (1937, p. 24), *solitaria* hoppers tend to assume the environmental colour in the field. This evidently refers to green hoppers only, since Rao makes no mention of fawn hoppers.

Roonwal (1937) performed a number of experiments by rearing Desert Locust hoppers solitarily in small, wooden boxes, each painted on the inside in different colours, *e.g.*, lemon yellow, prussian blue, mahogany, black, dark green, signal red, white and light ochre (unpainted wood). He concluded (p. 149) as follows: "It will be seen ... that some colours were apparently simulated, whereas in others the results were indefinite. Colours which were simulated to a greater or less extent were: lemon yellow, black, dark green and white. Hoppers reared in the mahogany-coloured boxes became fawn-coloured in the fourth stage. This is not regarded as due to the mahogany box, since a hopper reared in the prussian blue box also became fawn. *Moreover, the fawn colour sporadically appears in solitary hoppers in identically coloured cages where the factor of environmental colour cannot be correlated with the colour of the hopper*" (italicized now).

These results regarding colour simulation broadly confirm those obtained in similar experiments on *Locustana pardalina* and *Locusta migratoria migratorioides* by Faure (1932) in S. Africa, although the simulated

colours are not always the same as in the Desert Locust. In Faure's experiments simulation occurred in white, black, grey, yellow and brown boxes, but not in green, pink, blue and black and orange. In this connection the experiments of Hertz and Imms (1937) on *Locusta migratoria migratorioides* are also of great interest for, they explain colour-response in terms of wave length of the light emitted by the surroundings, i.e., of incident light to which the hoppers are subject.

In *gregaria* hoppers of the Desert Locust bred under identical conditions in the laboratory, Vayssi re and Lepesme (1939, p. 45.) record two extremes of colour-types with regard to background colour, viz., a greenish yellow and a rose, the former type being numerically predominant; in both types the pattern is black. They further state (p. 46) that the hoppers reared on a pale background are paler than those reared on a darker background; no further details are given, and it is not possible to say whether this statement refers to *solitaria* or *gregaria* hoppers.

It is thus seen that, so far as the Desert Locust is concerned, though simulation to environment occurs to a certain extent, the production of fawn hoppers in the *solitaria* phase is evidently an independent phenomenon which is related neither to environment nor to phase. It seems probable that the fawn and green colour-types among hoppers of the same phase (*solitaria*) have a genetical significance. The fawn hoppers, as regards colour, remind one strongly of the fawn adults described above, and it is very probable that the two colour-types in hoppers are related to the two colour-types in adults—the fawn hoppers producing fawn adults, and the green hoppers producing blue adults. This supposition is supported by the relative frequency (of about the same degree) of occurrence of fawn hoppers and fawn adults (about 10 per cent.) on the one hand, and green hoppers and blue adults (about 90 per cent.) on the other.

#### SUMMARY.

1. Two colour-types, termed *blue* and *fawn*, of *solitaria* adults occur in the Desert Locust. The blue type is predominant (91 per cent.), while the fawn type occurs less frequently (9 per cent.).
2. The occurrence of the two types of adults is not correlated with age, sex, season, E/F ratio, number of eye-stripes and phase.
3. Two colour-types also occur among *solitaria* hoppers of the Desert Locust, viz., the *green* type which is common and is already well-known, and a *fawn* type which occurs rarely. This colour distinction is well-marked in the older (fourth and fifth) stages.
4. The occurrence of these two types of hoppers is not related to food and environmental factors (e.g., background colour, etc.), nor to phase. It might possibly have a genetical significance.
5. It is probable, as is suggested by the relative frequency of their occurrence, that the two colour-types in the *solitaria* hoppers are related to the two colour-types in the *solitaria* adults—the green hoppers producing blue adults and the fawn hoppers producing fawn adults.

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ON VARIATION IN THE NUMBER OF OVARIOLES AND ITS PROBABLE ORIGIN IN THE DESERT LOCUST, *SCHISTOCERCA GREGARIA* (FORSKÅL). [ORTHOPTERA, ACRIDIDAE.]

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INTRODUCTION.

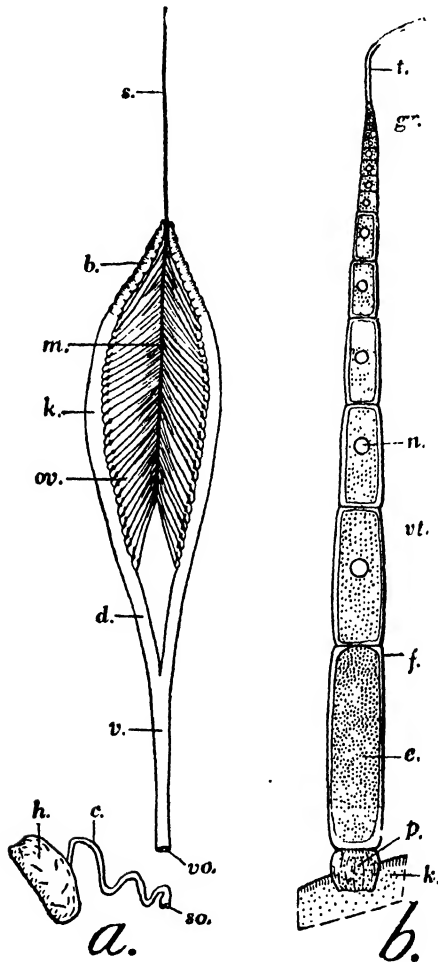
The Desert Locust, *Schistocerca gregaria* (Forskål), lays about 25 to over 100 eggs at each oviposition, the number varying from one oviposition to another and from female to female. This large number is to be coupled with an almost equally large number of ovarioles or eggs-tubes in the ovary, though the correspondence is not exact. Boldyrev (1929, p. 190) remarked for *Locusta migratoria* that "when a row of eggs matures, a certain percentage of the egg-tubes remains undeveloped, and the number of eggs produced is less than the number of egg-tubes". Nevertheless, in the Acrididae the number of ovarioles do provide us with a rough index of the number of eggs laid and thus of the reproductive capacity of the individuals. In this connection two problems, among several others, deserve consideration : (i) Is the difference in the reproductive rate under different environmental conditions, *e.g.*, at different temperatures and humidities, due to the reduction in the number of ovarioles ? (ii) Is there a difference in the number of ovarioles between the *gregaria* and *solitaria* phases, or between the various kinds of *solitaria* individuals (Roonwal, 1936, 1945-1946) ? Before, however, these and similar questions can be satisfactorily answered, we must know the natural variation in the number of ovarioles.

There are several accounts of the female reproductive organs of the Acrididae adults (Fénard, 1896, 1897 ; Berlese, 1909 ; Harman, 1925 ; Pospelov, 1926 ; Fedorov, 1927 ; Uvarov, 1928 ; Boldyrev, 1929 ; Nelsen, 1934 ; Snodgrass, 1935 ; Paoli, 1937 ; Jannone, 1938, 1939 ; Slifer, 1939-1943*a* ; Qadri, 1940 ; and others), and embryos and hoppers (Graber 1891 ; Nel, 1929 ; Nelsen 1934, 1934*a* ; Roonwal, 1937 ; and Qadri, 1940). Variation in the number of ovarioles, however, does not appear to have received attention except by Boldyrev (1929) and by Jannone (1938, pp. 318-319 ; 1939, pp. 280-281). Boldyrev noted in *Locusta migratoria* that the number of ovarioles varies in different individuals and in the right and left ovaries in the same individual. The total number, in eleven individuals, varied from 82-111, and the number in the right and left ovaries respectively from 40-55 and 42-56. The difference in the right and left ovaries of the same individual ranged from 0-4. In *Doclostaurus mroccanus* Jannone found no significant difference in the number of ovarioles between the phases *solitaria* and *transiens congregans* ; the number in each ovary is about 15-19, and that in both ovaries 30-37. An equal number in the two ovaries of a female is an exception rather than the rule. The first stage hopper has 15-16 ovarioles in each of the two ovaries.

I shall record here the variation in the number of ovarioles in the adults and hoppers of *Schistocerca gregaria* (phase *gregaria*) taken from various swarms in India. The probable mode of origin of asymmetry in the number of ovarioles in the right and left ovaries is also discussed.

#### THE OVARIES.

A brief description of the adult ovaries (Text-fig. 1), as observed in phase *gregaria*, may first be given. In an immature adult the two



TEXT-FIG. 1.—*Schistocerca gregaria* (Forsk.)

(a).—The ovary, its associated parts and the spermatheca of a freshly eclosed adult female. Dorsal view, with the antero-dorsal wall (not shown in the figure) of the genital cavity deflected backward. Semi-diagrammatic.  $\times$  about 6. (b).—An ovariole from the same. Semi-diagrammatic.  $\times$  about 60.

b., female accessory gland (*boyan calicinal*); c., canal of spermatheca; d., oviduct; e., developing egg; f., wall of basal ovarian follicle; gr., germarium; h., head of spermatheca; k., egg-calyx; m., median ligament; n., nucleus or germ-disc; ov., ovarioles; p., basal follicle or pedicel; s., ovarian suspensorium; so., spermathecal opening; t., basal portion of terminal filament of ovariole; v., common oviduct; vo., vaginal opening; vt., vitellarium.

ovaries are whitish, translucent bodies which measure about 7 mm. in length and 3 mm. in width and lie dorsal to the alimentary canal in the 4th to 6th abdominal segments. Each ovary is composed of a large and varying number of ovarioles (*ov.*). Each ovariole (Text-fig. 1*b*) consists of a chain of developing egg-cells, the oldest being at the base; towards the apex the ovariole passes into the terminal filament (*t.*). The ovarioles are disposed obliquely. The terminal filaments of the various ovarioles unite to form a median ligament (*m.*) which leads into the ovarian suspensorium (*s.*). The latter, in its turn, is attached to the dorsal body-wall of the mesonotum and holds the ovary in position. The ovarioles in each ovary lie close together in an obliquely longitudinal row of about 15-25 in a row, and roughly 2 or 3 deep. Each ovariole abuts on a muscular tube, the egg-calyx (*k.*), of its side which leads into the short (about 5 mm. long) oviduct (*d.*). The latter passes beneath the apodeme of the subgenital plate (8th sternum) and then bends inward to unite, below the alimentary canal, with its fellow of the opposite side to form the common oviduct or vagina (*v.*). The vagina opens into the "genital cavity" (*i.e.*, the exterior) near the posterior margin of the subgenital plate. In the same cavity, but more dorsally, lies the *independent* opening (*so.*) of the spermatheca<sup>1</sup>. Anteriorly, each egg-calyx leads into a single, blind, tubular and convoluted accessory gland or *boyau calicinal* (*b.*); abnormally, the *boyau calicinal* may possess an additional pouch (Roonwal, 1935). With maturity, the ovaries increase in size and also assume a yellow colour due to yolk in the ripening eggs. In a female about to oviposit the ovaries occupy the whole of the abdomen and also extend into the thorax; they then measure about 26 mm. long and 11 mm. wide.

#### THE NUMBER OF OVARIOLES IN ADULTS AND HOPPERS.

A total of 85 adult females from swarms was examined (Table 6), but later some of the readings were accidentally lost and only 49 were available for some purposes (Tables 1-4).

Table 1.

Number of ovarioles in right and left ovaries in 49 females of *Schistocerca gregaria* (phase *gregaria*, from swarms).

Serial No. .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Rt. ovary .	43	45	46	46	47	48	48	49	49	49	49	50	51	52	52	53	53	53
Lt. ovary .	49	54	54	54	48	55	52	54	52	58	54	53	54	53	70	40	63	53

<sup>1</sup>Qadri's (1940, p. 156) statement that the spermatheca opens on the common oviduct is incorrect both for *Locusta migratoria* (*vide* also Boldyrev, 1929; and several others) and *Schistocerca gregaria* (Karandikar, 1942; and the present account.) In fact in all the Acrididae so far studied the spermathecal opening is independent of the vaginal opening.



Table 1—continued.

Serial No. .	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Rt. ovary .	53	54	54	54	55	55	56	56	57	57	57	57	57	58	58	58	58	58
Lt. ovary .	53	53	47	53	63	53	81	50	56	52	54	51	51	72	55	58	48	59

Table 1—concluded.

Serial No. . . . .	37	38	39	40	41	42	43	44	45	46	47	48	49
Rt. ovary . . . . .	59	64	61	68	68	70	70	72	73	73	73	74	83
Lt. ovary . . . . .	51	57	45	68	53	66	73	73	68	72	69	69	53

Table 2.

Frequency distribution, etc. of the total number of ovarioles in the right and left ovaries of 49 individuals. [From Table 1.]  $n$ , number of ovarioles;  $f$ , frequency. (In the numerals within the range of  $n$  which are omitted,  $f=0$ .)

(a) Right ovary. Range 43-83; mean 57.3.

$n$	43	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	61	68	70	72	73	74	83
$f$	1	1	2	1	2	4	1	1	2	4	3	2	2	5	5	1	2	2	2	1	3	1	1

(b) Left ovary. Range 40-81; mean 57.2.

$n$	40	45	47	48	49	50	51	52	53	54	55	56	57	58	59	63	66	68	69	72	73	76	81
$f$	1	1	1	2	1	1	3	3	8	8	2	1	1	2	1	2	1	2	2	2	2	1	1

Table 3.

Frequency distribution, etc. of the difference in the number of ovarioles in the right and left ovaries in each of the 49 individuals. [From Table 1.] *d*, difference; *f*, frequency. (In the numerals within the range of *d* which are omitted, *f*=0.)

Range 0-30; mean 6.5.

<i>d</i>	0	1	2	3	4	5	6	7	8	9	10	13	14	15	19	24	25
<i>f</i>	4	8	1	6	3	5	1	3	1	2	2	1	1	1	1	1	1

The total number of ovarioles (in the right and left ovaries together) varied in 49 individuals from 92-145, mean 114.5 (Table 4). The number of ovarioles in the right and left ovaries in different individuals (Table 2*a, b*) varied from 43-83 (mean 57.3) in the right ovary, and 40-81 (mean 57.2) in the left; there is, thus, no appreciable difference in the mean number of ovarioles in the right and left ovaries of different individuals. In the same individual, however, the number of ovarioles in the right and left ovaries is usually asymmetrical (Table 3), the difference ranging from 0-30 (mean 6.5). As will be seen from Table 4, there appears to be no apparent relation between the difference in the number of ovarioles in the right and left ovaries and the total number of ovarioles in the two ovaries.

Regarding the mode of origin of this asymmetry, the following, I believe, provides a fairly satisfactory answer. Examination of a few hoppers of second to fifth stages<sup>2</sup> showed (Table 5) two significant features: (i) That the number of ovarioles in the hoppers is already large (2nd stage 118, 126; 3rd stage 116, 124; 4th stage 108, 116; 5th stage 116, 136). The number even in the second stage hopper most probably represents the full quota for the adult stage of that individual, since the number in the hopper stages is not appreciably smaller than that in the adult (*cf.* Table 4). It may be added that the ovarioles are already differentiated in the freshly-hatched first stage hopper, but, owing to their extreme compactness, their number could not be accurately counted; I am certain, however, that this number is large. (ii) That in all the eight cases, the number of ovarioles in the right and left ovaries is symmetrical.

<sup>2</sup> In the *grejaria* phase the Desert Locust has 5 hopper stages, exclusive of the vermiform larva. The 5th stage hopper moults into the adult.

Table 4.

Frequency distribution, etc. of the total number of ovaries in the two ovaries in each of the 49 individuals. [From Table 1.] *t*, total number; *f*, frequency; *d*, difference between right and left ovaries. (In the numerals within the range of *t* which are omitted, *f*=0.)

Range 92-145; mean 114.5.

<i>t</i>	.	.	.	.	92	93	95	99	100	101	103	105	106	107	108	109	110	111	113	116	117	118	121	128	130	136	137	141	142	143	145
<i>f</i>	.	.	.	.	1	1	1	1	3	2	4	2	4	3	3	2	1	1	2	2	1	1	2	1	1	3	1	1	1	2	2
<i>d</i>	.	.	.	.	6	13	1	9	4-8	3-7	3-7	1-3	0-10	1-9	2-6	5-10	8	3	1-3	0-10	1	8	7-15	24	14	0-30	25	5	4	3-5	

Table 5.

Number of ovarioles in the right and left ovaries in 8 hoppers of 2nd to 5th stages. *Rt.*, right ovary; *Lt.*, left ovary.

Stage	2nd		3rd		4th		5th	
Ovary	<i>Rt.</i>	<i>Lt.</i>	<i>Rt.</i>	<i>Lt.</i>	<i>Rt.</i>	<i>Lt.</i>	<i>Rt.</i>	<i>Lt.</i>
Number of ovarioles	63	63	58	58	54	54	68	68
	59	59	62	62	58	58	58	58

Again, a comparison of freshly eclosed or very young females with older females (nearing maturity or already mature) shows that in the 85 females which were examined (Table 6) the proportion of symmetrical or nearly symmetrical ovaries was much higher in young (42%) than in older females (29%). The criterion of symmetry adopted was that the difference in the number of ovarioles in the right and left ovaries in a female should not exceed 2.

Table 6.

Number and percentage of hoppers and adult females with symmetrical or nearly symmetrical ovaries.

Stage	Total number examined	Cases with symmetrical or nearly symmetrical ovaries	
		Number	%
Hoppers (2nd-5th stages)	8	8	100%
Freshly eclosed or very young females	19	8	42%
Females nearing maturity or already mature	66	19	29%

Though the number of specimens examined was rather small, the presence of symmetry in the hoppers and the greater frequency of symmetry in very young females as compared to mature ones, strongly suggest that the asymmetry is acquired not earlier than either the late hopper stages (late 5th) or some time after eclosion. The asymmetry probably arises by the unequal resorption in the right and left ovaries of the already differentiated ovarioles caused by competition for space and nutriment in a rapidly developing ovary crowded with ovarioles. This view finds support from the following observations.

In the ovary of a freshly hatched hopper all the ovarioles are of approximately the same size. Already in the fourth stage it is noticed that some ovarioles are markedly smaller than the others. In a mature female about to oviposit for the first time, though the majority of the ovarioles are large and each contains a ripe yellow egg in the basal follicle, there are some which are extremely underdeveloped and do not contain ripe eggs. This feature, incidentally, explains why the number of eggs laid is not equal to the number of ovarioles present in an ovary. Regarding the origin of the difference in the development of the various ovarioles which compose an ovary, there are two possibilities: (i) That the first differentiation of the ovarioles in an ovary does not occur at the same or nearly the same time. This is unlikely since the full quota of ovarioles is evidently differentiated even as early as the 2nd hopper stage (probably earlier), as is suggested by their large number and almost equal size in the early hopper stages. (ii) That in an ovary some ovarioles, though at first they start developing together with the others, lag behind in later development due to competition for space and nutrition. Owing to the causes already mentioned, some ovarioles are completely resorbed but in varying numbers in the right and left ovaries, thus leading to asymmetry.

#### SUMMARY.

1. The ovary of the Desert Locust is briefly described.
2. The number of ovarioles was examined in several adult females of phase *gregaria* (from swarms) and a few phase *gregaria* hoppers of second to fifth stages, and their natural variation analysed.
3. The total number of ovarioles in the two ovaries (right and left) varied in 49 females from 92-145, mean 114.5.
4. There was no significant difference in the mean number of ovarioles in the right and left ovaries in different individuals. The figures for 49 females were: right ovary 43-83, mean 57.3; left ovary 40-81, mean 57.2.
5. In the same female, however, the number of ovarioles in the right and left ovaries usually differs. The difference in 49 females was 0-30, mean 6.5. This asymmetry is absent in hoppers. It is evidently acquired in the late fifth stage hopper or in the young adult, and is accentuated with maturity in the adults.
6. The ovarioles are already differentiated in the freshly hatched hopper. Even in the 2nd stage hopper their number is large and probably represents the full quota for that individual; no further increase probably occurs.
7. At first (*i.e.*, in a freshly hatched first stage hopper) all the ovarioles in an ovary are subequal in size. Already in the 4th stage hopper, however, some of the ovarioles are markedly smaller than the others. The unequal development, probably caused by competition for space and nutrition, is accentuated as the ovary matures and, ultimately, a varying number of ovarioles is completely resorbed, thus leading to reduction and asymmetry in the right and left ovaries. The unequal development also explains why the number of eggs laid is smaller than the number of ovarioles.

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**MEGACEPON CHOPRAI, GEN. ET SP. NOV., A BOPYRID ISOPOD  
FROM THE GILL CHAMBER OF *SESARMA TETRAGONUM*  
(FABR.).**

By P. C. GEORGE, *The University Zoology Laboratory, Madras.*

While examining the branchial chamber of the semi-terrestrial crab, *Sesarma tetragonum*, collected from burrows on the banks of the Adyar River near Madras, a bopyrid was found attached to the gills. Other parasites were noticed even earlier in the gill chambers, but the present species attracted attention by its large size and feathery appendages. The specimen obtained was a female. Very careful examination of the gill chambers of thirty crabs captured from the same locality was subsequently made, but the bopyrid has not again been observed. Since the species does not agree with any of the known bopyrids, it is here described as new.

Family BOPYRIDAE.

**Megacepon, gen. nov.**

Female with one median dorsal tubercle on the last thoracic segment. All seven thoracic segments raised in the form of cushions. Exopodites present. Pleura of abdominal segments produced into long digitate prolongations. External as well as internal rami of pleopods equally modified. Uropods in the form of long feathery appendages.

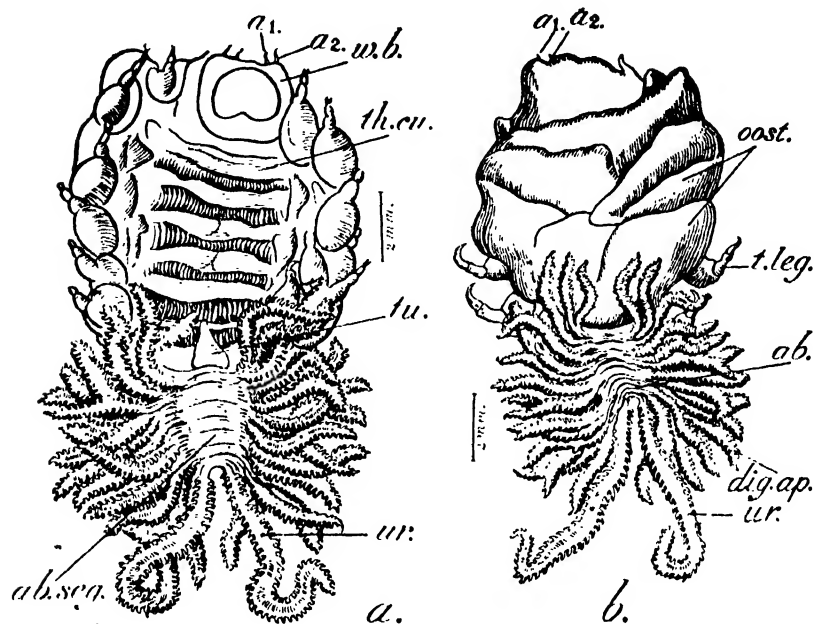
*Type-species.*—*Megacepon choprai*, sp. nov.

**Megacepan choprai, sp. nov.**

*Habitat and External Characters.*—The animal was alive when removed from the branchial chamber of the crab and it showed pulsations in the region of the neck. The movement stopped after a few minutes of exposure to air. It has a globular appearance, the convexity being greater on the ventral side. The large size of the animal is mainly due to the numerous feathery appendages in the abdominal region and to the cushion-like elevations on the dorsal side (Text-fig. 1a). The ventral side is completely masked by the incubatory plates (Text-fig. 1b), which are milky-white in colour. On the dorsal side are seen the rose-red lateral borders which stand out in sharp contrast to the milky white cushions and digitate appendages. The median dorsal tubercle is conical and can be seen prominently protruding from the last thoracic cushion. The head and the abdomen are in a lower plane when compared with the thorax, and the body tapers towards the posterior end



I have pleasure in naming this species after Dr. B. N. Chopra, the author of the Monograph on Bopyrid Isopods from Indian Decapods (1923).



TEXT-FIG. 1.—*Megacepon choprai*, gen. et. sp. nov. a. dorsal view; b. ventral view.

a1., first antenna; a2., second antenna; ab. seg., abdominal segment; dig. ap., digitate appendage; oost., oostegite; t. leg., thoracic appendage; th. cu., thoracic cushion; tu., tubercle; ur., uropod; w b., wavy border.

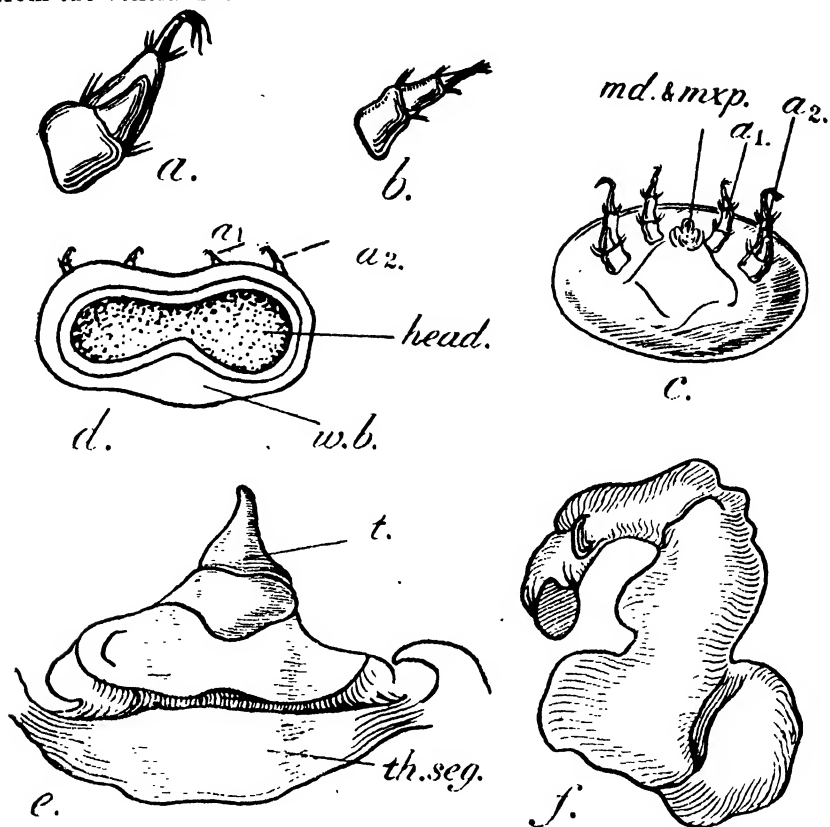
The following measurements were taken:—

Total length . . . . .	16 mm.
Length of the animal from the frontal border to the first abdominal segment . . . . .	9 mm.
Greatest width of the thorax . . . . .	8.5 mm.
Length of the head . . . . .	2 mm.
Length of the Uropod . . . . .	4.5 mm.
Length of a typical digitate appendage . . . . .	3 mm.

**The Head.**—The head (Text-fig. 2 d) is dumbbell-shaped with a wavy border, which is prominent on its posterior side. The thorax being very much larger in size, its first segment completely envelops the head.

The antennules (Text-fig. 2 b) are very small and are three-jointed. The first segment of the antennule is massive, while the last ends in tuft of hairs. The antennae (Text-fig. 2 a) are more prominent and each is five-jointed. The first article is consolidated with the head and the second is the largest in size, with a deep groove in it; the rest of the segments are slender. All the segments of the antennae show tufts of hairs at the base of each segment. The mandibles together with the

maxillipedes (Text-fig. 2 c) give a spoon-like appearance when viewed from the ventral side.



TEXT-FIG. 2.—*Megacepon choprai*, gen. et. sp. nov. a. second antenna; b. first antenna; c. ventral view of the head; d. dorsal view of the head; e. tubercle with the last thoracic segment; f. typical (4th) thoracic appendage; a1., first antenna; a2., second antenna; md., mandible; mxp., maxillipede; th. seg., thoracic segment; w.b., wavy border.

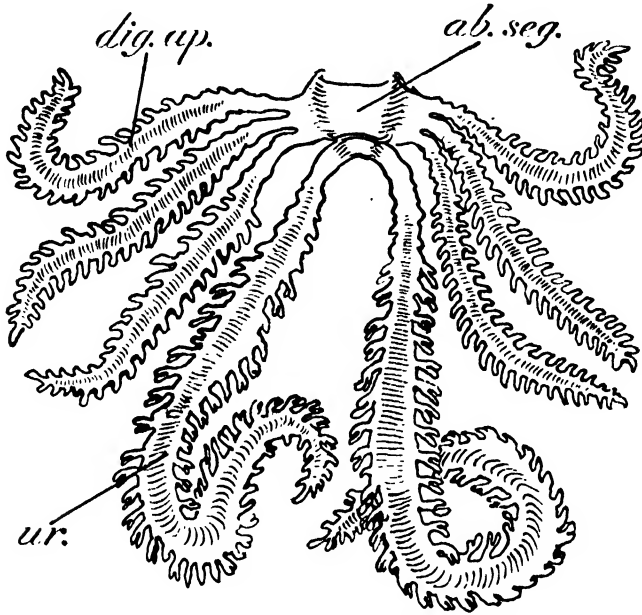
*The Thorax.*—The thorax forms the major part of the body of the animal and the entire globular form is brought about by the modification of the thoracic segments and the oostegites. There are seven thoracic segments, and all of them are in the form of cushions. These cushions are milky-white in colour, and are largest in size in the middle and taper towards the lateral regions, which are rose-red in colour in the living specimen. The third and fourth cushions show a groove in the middle, while the seventh bears a median dorsal tubercle, which is very prominent (Text-fig. 2 e).

The tubercle is cone-shaped and projects from the seventh cushion-like elevation.

On the ventral side, the thorax is covered by the oostegites, which are five in number on each side (Text-fig. 1 b). They are white in colour and are attached only by their posterior ends, and each oostegite is overlapped by the one behind it. The seven pairs of thoracic legs are well developed. They are massive, five-jointed and clawed at the

tips (Text-fig. 2 f). The incubatory lamellae mask the basal part of the legs. The penultimate segment of each thoracic leg has a few strong hairs at its base. The exopodites, though present, are short and stumpy.

*The Abdomen.*—The abdomen is comparatively slender and segmentation is more marked on the ventral side. The segments are



TEXT-FIG. 3.—Uropod with the last abdominal segment and pleopods of *Megacepon choprai*.

*ab. seg.*, abdominal segment; *dig. ap.*, digitate appendage; *ur.*, uropod.

more or less hidden from view by the overlapping of the digitate appendages. There are five pairs of pleopods. The pleura of the abdominal segments are modified into prolongations, and are digitate. The external as well as the internal rami of the pleopods are also modified into long digitate appendages. The abdomen is short and slightly bent towards one side. The uropods also consist of two long digitate processes, like those of the pleopods or the modified pleura of the abdominal segments (Text-fig. 3). The uropods are one and a half times longer than any one of the feathery appendages, which are more or less of the same length. There are sixteen digitate appendages on each side. Each abdominal segment has three processes, *viz.*, the exopodite, the endopodite and the pleural prolongation on each side. The digitate appendages have a pinnate appearance and the borders of the appendages are very transparent.

*Type-specimen.*—No. C 2480/1, Zoological Survey of India.

*Effect of Parasitism.*—The effect of parasitism on the host is also worth mentioning. The chelipeds were more or less disabled, and the walking legs were feebler in the parasitised crab than those in a healthy specimen. The gills on which the parasite was seen were of a greyish

Table showing generic characters of *Megacepon* and allied genera.

Generic Name.	Average Size.	Thorax.	Thoracic Appendages.	Abdomen.	Abdominal Appendages.	Uropod.	Host.
<i>Megacepon</i>	16 mm.	A median dorsal tubercle in the last thoracic segment; all segments raised as "cushions".	Thoracic legs well developed; short & stumpy exopodite.	Long & slender, segmentation marked; pleura modified to form long digitate prolongation.	Exopodite & endopodite modified to form digitate appendages similar to pleural prolongations.	1½ times longer than abdominal appendages; feathery and pinnate.	<i>Sesarma tetragnum</i> .
<i>Graptocepon</i>	1.9 mm.	Two dorsal tubercles in the last two thoracic segments; first four segments raised as "cushions".	Thoracic legs ill-developed; exopodites absent.	Long & slender; pleura modified to form long digitate appendages.	Exopodite alone modified to form digitate appendage; endopodite in the form of tubercles.	Uropod of same length as digitate appendages.	
<i>Trapezicepon</i>	Less than 5 mm.	Dorsal tubercle absent.	....	Pleura unmodified.	Pleopods fleshy and in the form of digitate appendages but rudimentary.	Uropod digitate and fleshy.	Trapezid crab.
<i>Portunicepon</i>	6 mm.	Dorsal tubercle absent	....	Pleura ill developed	Exopodites and endopodites developed but former smaller in length.	Uropod digitate and nearly equal in length to abdominal appendages.	<i>Portunus arcuatus</i> .

tinge and under the microscope, the lamellae showed signs of degeneration.

The present species is allied to some of the bopyrid parasites described in the Monographs on Isopod parasites by J. Bonnier (1900) and Miss H. Richardson (1905). The genera which are closely related to *Megacepon* are : *Grapsicepon* Giard and Bonnier (1887), *Trapezicepon* Bonnier (1900), and *Portunicepon* Bonnier 1900. It may be mentioned that Stebbing (1906) has described a bopyrid from crabs of the Indian region under the name *Tylokepon bonnierii* ; this is sharply demarcated from the above genera in the possession of two median tubercles of which one is trifid, of pleopods with unequal rami, and of a head " formed as it were of two short stout cylinders ". The principal characters of the closely allied genera, so far as females are concerned, are given on page 389 in a tabular form.

#### ACKNOWLEDGEMENT.

I gratefully acknowledge my indebtedness to Dr. N. Kesava Panikkar, Director, University Zoology Research Laboratory, Madras for his help and suggestions. I am also thankful to Dr. B. N. Chopra, who kindly read through this note and suggested improvements in the description.

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